

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
5 December 2002 (05.12.2002)

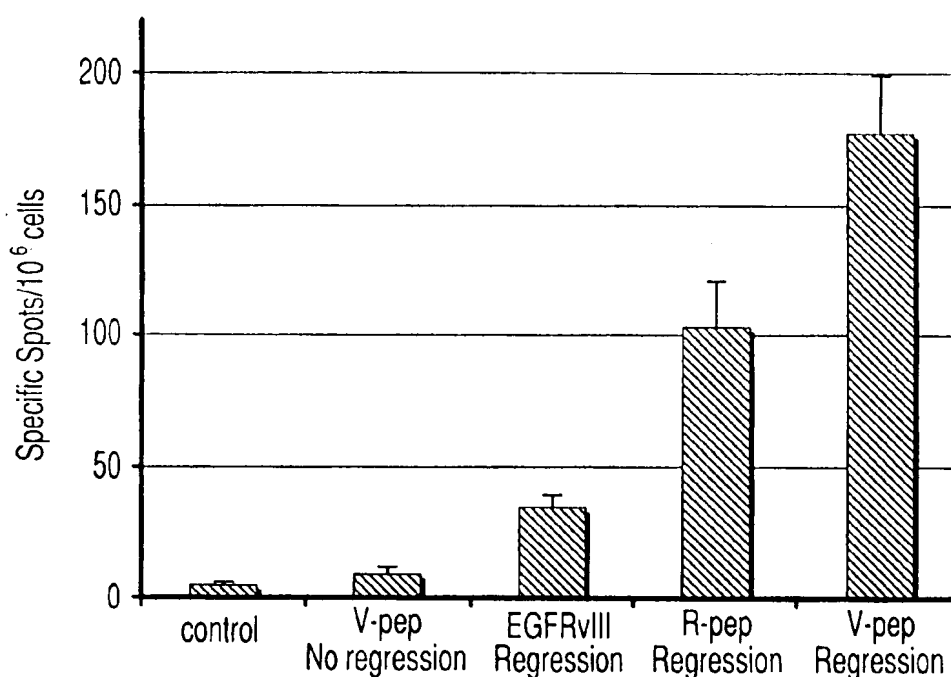
PCT

(10) International Publication Number  
**WO 02/097044 A2**

- (51) International Patent Classification<sup>7</sup>: **C12N**
- (21) International Application Number: **PCT/US02/16707**
- (22) International Filing Date: **28 May 2002 (28.05.2002)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:  
**60/293,791** **25 May 2001 (25.05.2001)** **US**
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- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: ALTERNATIVE SPLICE FORMS OF PROTEINS AS BASIS FOR MULTIPLE THERAPEUTIC MODALITIES



(57) Abstract: Peptides or antibodies derived from alternative splice forms of proteins associated with a disease or physiologic condition are used as therapeutic or prophylactic agents. Peptides or antibodies derived from alternative splice forms of the vascular endothelial growth factor (VEGF) family of proteins are particularly useful in preventing or delaying the onset of tumors and inducing tumor regression.

Serial No. 10/591,199  
Conf. No. 4302  
Group Unit: 1646



**WO 02/097044 A2**



**Published:**

— without international search report and to be republished upon receipt of that report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**ALTERNATIVE SPLICE FORMS OF PROTEINS AS BASIS FOR  
MULTIPLE THERAPEUTIC MODALITIES**

**Cross Reference to Related Applications**

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This application claims the benefit of co-pending U.S. Provisional Application Serial No. 60/293,791, filed May 25, 2001.

**Reference to Government Grant**

10

The invention described herein was supported in part by the National Institutes of Health, under grant no. CA69495. The government has certain rights in this invention.

**Field of the Invention**

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The present invention relates to the identification and use of alternative splice forms of proteins for the prophylactic or therapeutic treatment of tumors and other disease states.

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**Background of the Invention**

Traditionally, vaccines are derived from material completely foreign to the organism being vaccinated. Nevertheless, it is often desirable to immunize an organism with a vaccine based on proteins derived from the organism itself. For example, control of inflammation, prevention of ovulation or other forms of contraception, inhibition of Alzheimer's disease, and prevention or inhibition of tumor growth are all conditions which benefit from immunization with endogenous or "self" proteins.

Peptide vaccines can be used to treat subjects with diseased or abnormal cells; for example, cells infected with viruses, intracellular bacteria or parasites, and tumor cells. The peptide vaccine can induce a cytotoxic T lymphocyte (CTL) response against the diseased or abnormal cells. Cytotoxic T lymphocytes (CTLs) destroy diseased or abnormal cells by direct cytotoxicity, and by providing specific and nonspecific help to other immunocytes such as macrophages, B cells, and other types of T cells. Peptide vaccines can also induce an antibody response, which is useful in the prophylactic and therapeutic treatment of the disease or condition.

Current peptide vaccine technology involves identification of an endogenous normal protein which is associated with the pathogenesis of a given condition. The normal whole protein is then used as the basis for a vaccine. Alternatively, portions of the endogenous protein which are predicted to bind to MHC class I or II motifs are identified and used to produce the vaccine. See Falk et al., *Nature* 351:290, 1991. However, peptide vaccines made only from the partial or whole normal protein sequences can be poorly immunogenic against diseased or abnormal cells, and can also induce an immune reaction against those cells of the body which express the normal protein.

Previous attempts to increase the specific immunogenicity of peptide vaccines have focussed on point mutations in endogenous proteins from various types of cancer cells. These point mutations represent a small area of "non-self" within the larger endogenous protein sequence that may be used to elicit an immune response. However, these point mutations are not effectively recognized by the immune system, and peptide vaccines employing such technology have not produced strong immunologic responses.

Peptide vaccines have also been based on the protein products resulting from gene rearrangements (*i.e.*, deletions, chromosomal rearrangements) that are sometimes present in cancer cells. For example, a chromosome 9:22 translocation in chronic myelogenous leukemia cells produces the BCR/Abl fusion protein. This protein contains an area of "non-self" at the BCR/Abl fusion junction, and has elicited some immunologic response in human patients. However, such gene rearrangements are rare, and chromosomal translocations

are only known to occur in cancer. Thus, the usefulness of vaccines produced from protein products derived from chromosomal rearrangements is limited.

Thus, it is desirable to identify endogenous proteins which are specific to certain tissues in a given disease state, and which also contain immunologic areas of "non-self" that produce a strong immune response, such as a CTL or antibody response. Ideally, such altered endogenous proteins would be commonly occurring and induce little or no cross-reactivity to the corresponding normal protein.

Primary RNA transcripts from certain genes can undergo alternative splicing to produce messenger RNA (mRNA) which differs from the majority of the mRNA produced by the gene. These alternatively spliced mRNAs are translated into alternative splice form proteins that contain different amino acid sequences than the corresponding protein produced by normally spliced mRNA. Alternative splice form proteins are often expressed in a tissue-specific manner under certain physiologic or disease states. Consequently, these alternative splice forms are present in a limited number of cells in a subject suffering from a given disease or condition. For example, it is known that many types of cancer cells produce alternative splice forms which are not found in normal cells from the same subject. Other disease states in which alternative splice forms are specifically produced include diabetes, Alzheimer's disease and systemic lupus erythematosus (SLE). These alternative splice forms have not heretofore been recognized as a source for vaccines directed against cells from diseased or abnormal tissue which produce the alternative splice form.

## **Summary of the Invention**

It has now been found that peptides derived from alternative splice forms of proteins produced in diseased or abnormal cells are highly immunogenic. Such peptides elicit a strong immune response specific to the "non-self" portion of the peptide. In particular, the peptides can elicit a specific CTL response. The peptides can be used in the therapeutic or prophylactic treatment of a disease or condition which is characterized by the presence of the alternative splice form in certain cells.

The invention thus provides a peptide comprising an amino acid sequence unique to an alternative splice form, wherein the alternative splice form is produced by diseased or abnormal cells of a subject but is substantially absent from the subject's normal cells.

5       The invention also provides a method of identifying immunogenic peptides for treating a subject who has, or is at risk for having, a disease or condition in which diseased or abnormal cells produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells. The method comprises the steps of identifying at least one mRNA which  
10       encodes for the at least one alternative splice form; determining at least a partial amino acid sequence of the at least one alternative splice form; and generating at least one peptide comprising an amino acid sequence which is unique to the alternative splice form.

      The invention also provides a method of treating a subject who has, or is  
15       at risk for having, a disease or condition in which diseased or abnormal cells produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells. The method comprises administering to the subject an effective amount of at least one peptide comprising an amino acid sequence which is unique to the alternative splice form such that an immune  
20       response is generated against the diseased or abnormal cells.

      The invention further provides a method of preventing or delaying the onset of tumor development in a subject at risk for having a tumor in which tumor cells produce at least one alternative splice form, which alternative splice form is substantially absent from non-tumor cells. The method comprises  
25       administering to a subject an effective amount of at least one peptide comprising an amino acid sequence which is unique to the alternative splice form, such that an immune response is generated against the tumor cells.

      The invention further provides a method of regressing a tumor in a subject having a tumor in which tumor cells produce at least one alternative  
30       splice form, which alternative splice form is substantially absent from non-tumor cells. The method comprises administering to a subject an effective amount of at least one peptide comprising an amino acid sequence which is

unique to the alternative splice form, such that an immune response is generated against the tumor cells.

The invention also provides a method for identifying peptides of the invention which induce MHC-restricted cytotoxic T lymphocyte responses in a  
5 subject, comprising obtaining peripheral blood lymphocytes (PBLs), exposing the PBLs to one or more of the peptides such that the PBLs are stimulated, incubating the stimulated PBLs with target cells that either endogenously synthesize the alternative splice form from which the peptide is derived or are pulsed with peptide, and detecting lysis of the target cells.

10 For example, the target cells can be autologously labeled with a radioactive or fluorescent substance. Detecting lysis of the target cells can be accomplished by measuring the amount of autologous label released from the target cells which are lysed by the activated PBLs. Lysis of the target cells can also be detected with an enzyme-linked immunospot ("ELISPOT") assay.

15 The invention also provides antibodies that bind to specific epitopes on alternative splice forms or peptides comprising an amino acid sequence unique to an alternative splice form. The antibodies can be monoclonal or polyclonal, or can be an antibody fragment that is capable of specifically binding to an alternative splice form epitope.

20 The invention also provides a hybridoma that produces a monoclonal antibody which specifically binds alternative splice forms or peptides comprising an amino acid sequence unique to an alternative splice form.

The invention further provides a method of treating a subject having, or at risk for having, a disease or condition in which diseased or abnormal cells  
25 produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells. The method comprises administering to a subject an effective amount of at least one antibody specific to an amino acid sequence unique to the alternative splice form, such that one or more clinical symptoms in the subject are ameliorated, or the number of diseased or abnormal  
30 cells in the subject is reduced.

### Amino Acid Abbreviations

The nomenclature used to describe the peptide compounds of the present invention follows the conventional practice wherein the amino group is presented to the left and the carboxy group to the right of each amino acid residue. In the formulae representing selected specific embodiments of the present invention, the amino-and carboxy-terminal groups, although not specifically shown, will be understood to be in the form they would assume at physiologic pH values, unless otherwise specified. In the amino acid structure formulae, each residue is generally represented by a one-letter or three-letter designation, corresponding to the trivial name of the amino acid, in accordance with the following schedule:

	A	Alanine	Ala
	C	Cysteine	Cys
15	D	Aspartic Acid	Asp
	E	Glutamic Acid	Glu
	F	Phenylalanine	Phe
	G	Glycine	Gly
	H	Histidine	His
20	I	Isoleucine	Ile
	K	Lysine	Lys
	L	Leucine	Leu
	M	Methionine	Met
	N	Asparagine	Asn
25	P	Proline	Pro
	Q	Glutamine	Gln
	R	Arginine	Arg
	S	Serine	Ser
	T	Threonine	Thr
30	V	Valine	Val
	W	Tryptophan	Trp
	Y	Tyrosine	Tyr

### Definitions

35

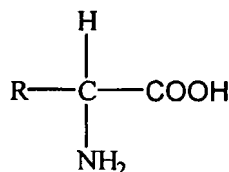
The expression “**amino acid**” as used herein is meant to include both natural and synthetic amino acids, and both D and L amino acids. “**Standard amino acid**” means any of the twenty L-amino acids commonly found in naturally occurring peptides. “**Nonstandard amino acid**” means any amino



acid, other than the standard amino acids, regardless of whether it is prepared synthetically or derived from a natural source. As used herein, "synthetic amino acid" also encompasses chemically modified amino acids, including but not limited to salts, amino acid derivatives (such as amides), and substitutions.

- 5 Amino acids contained within the peptides of the present invention, and particularly at the carboxy- or amino-terminus, can be modified by methylation, amidation, acetylation or substitution with other chemical groups which can change the peptide's circulating half life without adversely affecting their biological activity. Additionally, a disulfide linkage may be present or absent in  
10 the peptides of the invention.

Amino acids have the following general structure:



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Amino acids are classified into seven groups on the basis of the side chain R: (1) aliphatic side chains, (2) side chains containing a hydroxylic (OH) group, (3) side chains containing sulfur atoms, (4) side chains containing an acidic or amide group, (5) side chains containing a basic group, (6) side chains  
20 containing an aromatic ring, and (7) proline, an imino acid in which the side chain is fused to the amino group.

"Antibody" as used herein includes polyclonal and monoclonal antibodies, chimeric, single chain, chimeric and humanized antibodies, as well as Fab fragments, including the products of an Fab or other immunoglobulin  
25 expression library.

The term "**humanized antibody**" refers to an antibody that has its complementary determining regions (CDRs) derived from a non-human species immunoglobulin, and the remainder of the antibody molecule derived from a human immunoglobulin.

30 The term "**chimeric antibody**" means an antibody comprising a variable region and a constant region derived from different species.

The term “chimeric humanized antibody” is meant a chimeric antibody in which at least the constant region is human-derived.

“Peptide” and “protein” are used interchangeably, and refer to a compound comprised of at least two amino acid residues covalently linked by peptide bonds or modified peptide bonds (*e.g.*, peptide isosteres). No limitation is placed on the maximum number of amino acids which may comprise a protein or peptide. The amino acids comprising the peptides or proteins described herein and in the appended claims are understood to be either D or L amino acids with L amino acids being preferred. The amino acid comprising the peptides or proteins described herein may also be modified either by natural processes, such as posttranslational processing, or by chemical modification techniques which are well known in the art. Modifications can occur anywhere in a peptide, including the peptide backbone, the amino acid side-chains and the amino or carboxyl termini. It is understood that the same type of modification may be present in the same or varying degrees at several sites in a given peptide. Also, a given peptide may contain many types of modifications. Modifications include acetylation, acylation, ADP-ribosylation, amidation, covalent attachment of flavin, covalent attachment of a heme moiety, covalent attachment of a nucleotide or nucleotide derivative, covalent attachment of a lipid or lipid derivative, covalent attachment of phosphatidylinositol, cross-linking, cyclization, disulfide bond formation, demethylation, formation of covalent cross-links, formation of cystine, formation of pyroglutamate, formylation, gamma-carboxylation, glycosylation, GPI anchor formation, hydroxylation, iodination, methylation, myristoylation, oxidation, proteolytic processing, phosphorylation, prenylation, racemization, selenoylation, sulfation, transfer-RNA mediated addition of amino acids to proteins such as arginylation, and ubiquitination. See, for instance, Proteins - Structure and Molecular Properties, 2nd Ed., T. E. Creighton, W. H. Freeman and Company, New York, 1993 and Wold F, Posttranslational Protein Modifications: Perspectives and Prospects, pgs. 1-12 in Posttranslational Covalent Modification of Proteins, B. C. Johnson, Ed., Academic Press, New York, 1983; Seifter et al., “Analysis for protein modifications and nonprotein cofactors,” *Meth. Enzymol.* (1990) 182: 626-646

and Rattan et al. (1992), "Protein Synthesis: Posttranslational Modifications and Aging," *Ann NY Acad Sci* 663: 48-62.

As used herein, "**reading frame**" means a specific series of codons in a nucleic acid, for example an mRNA, which produce a given polypeptide when translated.

### **Brief Description Of The Figures**

**Figure 1A** is a photograph of an agarose gel electrophoresis showing the PCR product representing alternative splice form #1 in VEGFD (SEQ ID NO: 77). Shown is the third round of PCR using primer set 3. The strong band of ~300 bp (labeled as "VEGFD#1") represents SEQ ID NO: 77; the band of 1082 bp (labeled as "VEGFD") represents the expected normally spliced mRNA. M: molecular weight in bp; HC2: PCR amplification from HC2 20d2/c cells.

**Figure 1B** is a photograph of an agarose gel electrophoresis showing the results of the PCR amplification of NIH-3T3 cells. Shown is the third round of PCR using primer set 3. Only the band corresponding to the expected normally spliced mRNA is present (labeled as "VEGFD"). M: molecular weights in bp; NIH: PCR amplification from NIH-3T3 cells.

**Figure 2** is a plot of average tumor volumes in mm<sup>3</sup> vs. time in days for NIH-Swiss mice vaccinated with various immunogenic peptides derived from VEGF family alternative splice forms.

**Figures 3A and 3B** are survival plots of number of tumors per mouse vs. days after birth and total tumor volume in each mouse vs. days after birth, respectively, for MMTV-neu mice treated with immunogenic peptides derived from VEGF family member alternative splice forms. For both figures, nine litter mate female mice either are left untreated ("No treatment"), given GM-CSF only ("GM-CSF"), or given a combination of VEGF family based alternative splice form vaccines with GM-CSF ("Combo"). Each curve on the survival plots represents a single animal.

**Figure 4** shows autoradiographs of dot blots measuring the antibody response in MMTV-Neu mice which were A) left untreated ("No Treat"), B) given GMCSF alone ("GM-CSF"), or C) vaccinated with a combination of SEQ

ID NO: 73, SEQ ID NO: 77 and SEQ ID NO: 81 and GM-CSF ("COMBO"). The antibody response in the mice was measured against 1 microgram of BSA, SEQ ID NO: 82 ("EGFRvIII"), SEQ ID NO: 73 ("R-pep"), SEQ ID NO: 81 homodimer ("RC-pep"), SEQ ID NO: 77 ("H-pep"), SEQ ID NO: 79 ("L-pep"), or SEQ ID NO: 75 ("V-pep") spotted onto nitrocellulose membranes.

**Figure 5** is a plot showing lytic events identified using the ELISPOT assay with anti-interferon-gamma antibody. Splenocytes isolated from mice inoculated with HC2 20d2/c tumor cells and then immunized with SEQ ID NO: 73 ("R-pep"), SEQ ID NO: 75 ("V-pep") or SEQ ID NO: 82 ("EGFRvIII") plus GM-CSF that showed tumor regression, or from a mouse inoculated with SEQ ID NO: 75 ("V-pep") and GM-CSF that showed no regression were evaluated in the assay. Mice inoculated with GM-CSF only were used as a control ("control").

15

### **Detailed Description Of The Invention**

Alternative splice forms (also referred to as "alternative splice form proteins") comprise amino acid sequences not found in the corresponding normal proteins. An amino acid sequence found only in the alternative splice form and not in the corresponding normal protein is considered "unique" to the alternative splice form.

Peptides comprising amino acid sequences which are unique to alternative splice forms are therefore highly immunogenic. As used herein, a "normal" protein is any protein produced from mRNA transcripts which comprise the majority of the total mRNA transcripts produced by a given gene. For example, if two mRNA transcripts are produced by a gene, the mRNA transcript which comprises greater than 50% of the total mRNA transcripts produced by the gene is considered a normally spliced mRNA transcript which is translated into the "normal" protein. The mRNA transcript which comprises less than 50% of the total mRNA produced by the gene is considered an alternatively spliced mRNA, and is translated into an alternative splice form. If three or more mRNA transcripts are produced from a gene, the mRNA transcript which is present in the greatest proportion relative to the other mRNA

transcripts is considered a normally spliced mRNA transcript which is translated into the "normal" protein. Those mRNA transcripts which are present in lesser proportions relative the normally spliced mRNA are considered an alternatively spliced mRNA, and are translated into alternative splice forms. By way of example, if a gene produces three mRNA transcripts in the relative proportions of 40:35:25, the mRNA which comprises 40% of the total mRNA transcripts produced is considered the normally spliced mRNA. The two mRNA transcripts comprising, respectively, 35% and 25% of the total mRNA transcripts produced are considered alternative splice forms.

For purposes of the invention, it is assumed that the level of normal or alternatively spliced mRNA produced by a gene is directly proportional to the level of protein produced from the mRNA. The amount of alternatively spliced mRNA, and thus of alternative splice form, in a cell is often a relatively small proportion of the total mRNA transcripts produced by the gene. For example, the alternative splice form can represent 10% or less, 5% or less, 1% or less or 0.5% to 0.1% or less of the total output of a given gene.

The relative amount of mRNA transcripts produced from a gene can be measured by techniques well-known in the art; for example by quantitative reverse-transcriptase polymerase chain reaction (RT-PCR) techniques such as those described in Siebert PD (1993), "Quantitative RT-PCR," Clontech Laboratories, Inc., Palo Alto, CA; Carango P et al. (1995), *Ann. Neurol.* 38: 610-617; and Grove DS (1999), *J. Biomolecular Techniques* 10: 11-16, the entire disclosures of which are herein incorporated by reference. Amounts of mRNA transcripts are typically expressed in relative units (e.g., relative fluorescence units), but can be expressed in terms of mass (e.g., micrograms) or moles (e.g., gram molecular weight).

The amount of an alternative splice form in a diseased or abnormal cell (as evaluated either at the protein or mRNA level) can be at least 50% greater than the level of the same alternative splice form which is found in a normal cell. A "diseased" or "abnormal" cell is identified by certain phenotypic abnormalities which are readily recognized by those skilled in the art upon examination of cells or tissue. For example, the pathology and histopathology

of different cancers is described in Cancer: Principles and Practice of Oncology, (3rd edit., DeVita VT, Hellman S, and Rosenberg SA, eds.), 1989, J. B. Lipincott Co., Phila., PA, the entire disclosure of which is herein incorporated by reference.

5           Cells which are tumorigenic or neoplastic can also be identified by certain growth characteristics and morphology exhibited by the cell in culture. Tumorigenic or neoplastic cells are insensitive to contact-induced growth inhibition, and the cells form foci in the culture vessel when cultured for extended periods. Tumorigenic or neoplastic cells also exhibit characteristic  
10   morphological changes, disorganized patterns of colony growth, and the acquisition of anchorage-independent growth. Tumorigenic or neoplastic cells also have the ability to form invasive tumors in susceptible animals, which can be assessed by injecting the cells, for example, into athymic mice or newborn animals of the same species using techniques well-known in the art. See, for  
15   example, Combes et al. (1999), "*Cell Transformation Assays as Predictors of Human Carcinogenicity: The Report and Recommendations of ECVAM Workshop 39*," *ATLA* 27, 745-767, available at: <http://altweb.jhsph.edu/science/pubs/ECVAM/ecvam39.htm>, the entire disclosure of which is herein incorporated by reference.

20           Histological, cell culture-based, and other techniques for identifying other types of diseased or abnormal cells are also well-known in the art.

          As used herein, an alternative splice form which is "substantially absent from normal cells" means the alternative splice form is not present in the normal cells or is present in a negligible amount, and in any case is not present in more  
25   than about 66% of the level found in a diseased or abnormal cell. An immune response directed specifically against diseased or abnormal cells can therefore be generated in a subject by administering one or more peptides comprising amino acid sequences which are unique to the alternative splice form. Immunization with such peptides has the advantage of not eliciting an immune  
30   response against normal cells.

          One type of alternative splice form contains a novel amino acid sequence formed by the joining of two normally distant amino acid sequences. This type

of alternative splice form is created when an mRNA is spliced so as to skip all or part of an exonic sequence which is normally translated into the protein, but which leaves the normal reading frame intact. A novel amino acid sequence is thus created at the "splice junction" by the juxtaposition of two "normal" amino acids which were not heretofore adjacent. Amino sequences from the normal protein flank the splice junction. The skipping of exonic sequences may also create a new codon without shifting the reading frame of the mRNA. In this instance, a new amino acid is inserted at the splice junction which is flanked by normal amino acid sequences. Both types of splice junctions are considered immunologic "non-self" sequences.

Another type of alternative splice form contains novel amino acid sequences translated from coding sequences which are not normally present in the mRNA. Such coding sequences are created by alternative splice events in which intronic sequences, or exonic sequences not typically translated into the normal protein, are included in the mRNA. The coding sequences can also be created by alternative splicing events which alter the native reading frame of the mRNA, resulting in translation of a "missense" amino acid sequence downstream of the alternative splice site. The novel amino acid sequences are considered immunologic "non-self" sequences.

Genes which are involved in a particular disease process, and which are likely to produce alternatively spliced mRNAs, often exhibit altered expression patterns in diseased or abnormal cells as compared to cells from normal tissue.

For example, angiogenesis (the formation of new blood vessels) is a critical process for the continued growth of tumors. Some of the most potent factors for angiogenesis identified in tumors are members of the vascular endothelial growth factor (VEGF) protein family, which are upregulated in tumor cells. The VEGF proteins include VEGF, VEGF-B, VEGF-C, VEGF-D, and placental growth factor (PlGF). The mRNA which produces the VEGF proteins can undergo a variety of splicing events.

Many other genes which produce alternatively spliced mRNAs in a disease-specific manner are known in the art, and can be used in the practice of the present invention. Table 1 contains a representative list of such genes, the

diseases or conditions with which they are associated, the alternative splice forms produced by those genes, and peptides of the invention derived from the alternative splice forms.



**Table 1**

<u>Disease</u>	<u>Journal reference</u> <sup>1</sup>	<u>Gene affected (category of protein)</u>	<u>Nature of alternative splice and sequence of peptide derived from alternative splice form</u>	<u>GenBank accession number of gene or gene product<sup>2</sup> and SEQ ID NO. of alternative splice form (full or partial sequence)</u>
<b>Acute promyelocytic leukemia</b>	Proc. Natl. Acad. Sci. (USA) 99:7640-7645 (2002)	Retinoic acid receptor-alpha (signal transduction protein)	Inclusion of 2 <sup>nd</sup> intron in RAR-alpha gene, in-frame (underlined): NSNHV ASGAPVCHNPNLPSWOGALGP YGVVVLAPDTWLSSLRLSSSPGVEGRS CSARETQA [SEQ ID NO: 3]	AC090426
<b>Myeloblastic leukemia</b>	J. Biol. Chem., Vol. 275, Issue 33, 25255-25261	MCL-1 (transcription factor)	Novel sequences after junction: RNHETAFQ^GWVCGVLPQR [SEQ ID NO: 2]	AF203373 [SEQ ID NO: 1]
<b>Response to stress, infection</b>	J. Biol. Chem., Vol. 276, Issue 31, 29037-29044	Interleukin-1 Receptor-associated Kinase (signal transduction)	In-frame deletion of 30 amino acids (residues 514-543). Deleted region is VYERLEKLQAVVAGVPGHLEAASCIPP SRQ [SEQ ID NO 5]	U52112 [SEQ ID NO: 4]

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<b>Thyroid hormone repression</b>	J. Biol. Chem., Vol. 276, Issue 51, 48196-48205	Branched-chain Amino transferase (metabolism)	36-bp gap (corresponding to nucleotides 1030-1065 of BCA Tm) located near the carboxyl terminus	U68418 [SEQ ID NO: 6]
<b>Immunity/ inflammation</b>	J Biol Chem, Vol. 274, Issue 39, 27857-27866	Human Glucocorticoid Receptor Beta Isoform (signal transduction)	hGRbeta has additional nonhomologous 15 amino acids at C terminus.	
<b>Oncogenic progression</b>	J Biol Chem, Vol. 273, Issue 43, 28208-28218	Bile salt-dependent lipase (BSDL) (body metabolism)	Underlined is novel sequence: <u>APVPPTGDSGAPPVPP</u> [SEQ ID NO: 8]	AF081673 [SEQ ID NO: 7]
<b>Endothelial cell activation</b>	J Biol Chem, Vol. 274, Issue 3, 1415-1422	Variant of <i>HOXA9</i> (transcription factor)	Inframe junction of sequences: DKPPIDP^NNP^AANW [SEQ ID NO: 10]	U82759 [SEQ ID NO: 9]
<b>Regulation of Folate</b>	J Biol Chem 271:23820-23827	Folypolyglutamate Synthetase Gene (metabolism)	Alternate exon: AVSARGATTEGPARRGMS [SEQ ID NO: 12]	U33557 [SEQ ID NO: 11]
<b>Cancer</b>	J. Biol Chem, 267: 4732-4739, 1992	CD44 splicing variants (cell adhesion/signal transduction)	Five different splicing variants inserted into CD44 coding sequence, all inframe	M83324 [SEQ ID NOS: 13 & 14] M83325 [SEQ ID NOS: 15 & 16] M83326 [SEQ ID NOS: 17 & 18] M83327 [SEQ ID NOS: 19 & 20] M83328 [SEQ ID NOS: 21 & 22]
<b>Uterine cancer</b>	Cancer Research, Vol. 54, Issue 13 3337-3341	CD44	Containing variant exons v3 to v10, including the v7/v8 transition epitope	

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<b>Thyroid cancer</b>	Cancer Research, Vol. 56, Issue 5 1037-1042	CD44	Contains subsegment from exon 4 joined to a subsegment of exon 13 (v8), followed by the complete sequence of exons 14 and 15	
<b>Gastrointestinal tumors</b>	Cancer Research, Vol. 55, Issue 19 4273-4277	CD44	Retention of intron 9	
<b>Dysplastic, and neoplastic cervical epithelium</b>	Clinical Cancer Research, Vol. 1, Issue 10 1125-1132	CD44 variants		
<b>Melanoma</b>	Clinical Cancer Research, Vol. 2, Issue 3 447-456	CD44 variants		
<b>Atherosclerosis</b>	J Biol Chem 268:17528-17538, 1993	Variant of Human VLDL receptor (lipid metabolism)	Lacks 84 nucleotides	
<b>Allergic response</b>	J Biol Chem 264: 5912-5915	Variants of IgE receptor alpha chain (receptor/signal transduction)	Exon 2 or part of exon 4 missing	

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<b>Cardiac Function</b>	J. Biol. Chem. In press	Sarco/Endoplasmic Reticulum Ca <sup>2+</sup> -ATPase (SERCA) 3 isoforms (ion channels)	Three novel splice forms	AF458230 [SEQ ID NO: 23] AF458229 [SEQ ID NO: 24] AF458228 [SEQ ID NO: 25]
<b>Breast Cancer</b>	<i>Cancer Research</i> 59, 2546-2550	<i>BRCA2</i> (DNA repair)	Junction of exon 11 to 13 inframe LILVGEPSI <sup>Δ</sup> STPDGTIK [SEQ ID NO: 26]	U43746 [SEQ ID NO: 27]
<b>Prostate Cancer</b>	<i>Cancer Research</i> , Vol. 54, Issue 5 1190-1193	Estrogen receptor	Variant lacking all of exon 4	
<b>Breast Cancer</b>	<i>Cancer Research</i> , Vol. 53, Issue 24 5934-5939	Constitutively active estrogen receptor (hormone metabolism/signal transduction)	Lack of exon 5	
<b>Breast Cancer</b>	<i>Cancer Research</i> , Vol. 56, Issue 19 4324-4327	exon 4-deleted estrogen receptor mRNA, deleted in exons 2-4 or in regions within exons 3-7		
<b>Small Cell lung cancer</b>	<i>Cancer Research</i> 60, 1840-1844	Neuron-restrictive Silencer Factor Repressor (transcriptional regulation)	Novel exon inserted: VGYGYHLVIFTRV [SEQ ID NO: 29]	AF228045 [SEQ ID NO: 28]

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<b>Lung Cancer</b>	Cancer Research, Vol. 57, Issue 11 2256-2267	FHIT gene (nucleotide metabolism)	Various deletions of coding exons or insertions of novel exons	
<b>Breast Cancer</b>	Cancer Research, Vol. 56, Issue 21 4871-4875	FHIT gene (nucleotide metabolism)	Additional 32 amino acids at amino terminus due to splicing	
<b>Breast Cancer</b>	Cancer Research 59, 4190-4193	Steroid Receptor RNA Activator (hormone metabolism)	Deletion of 203 bp between positions 155 and 357 [SEQ ID NO: 31]	AF092038 [SEQ ID NO: 30]
<b>Acute lymphoblastic leukemia</b>	Cancer Research, Vol. 56, Issue 9 2171-2177	ALL-1 gene (transcription factor)	Deletion of exon 8	
<b>Endometrial hyperplasia</b>	Cancer Research, Vol. 58, Issue 12 2500-2503	PTEN gene (signal transduction)	4 bp deletion in exon 8	
<b>Endometrial Cancer</b>	Cancer Research, Vol. 57, Issue 24 5579-5583	Sex hormone binding globulin (hormone metabolism)	Deletion of entire exon VII	
<b>Teratocarcinoma</b>	Cancer Research, Vol. 54, Issue 1 220-225	PDGF-alpha receptor (receptor/signal transduction)	Lacks exon 14	
<b>Colon Cancer</b>	Cancer Research, Vol. 56, Issue 8 1731-1736	DT-diaphorase (drug detoxification)	Deletion of exon 4	
<b>Breast Cancer</b>	Clinical Cancer Research Vol. 6, 1135-1139		p66 isoform	

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<b>Desmoplastic round cell tumors</b>	Clinical Cancer Research Vol. 6, 3522-3529	EWS gene (transcription factor)	Deletion of exons 5, 6, 7 or 8	
<b>Muscle development</b>	Proc. Natl Acad Sci 92:2686-2690	Nicotinic acetylcholine receptor (neurotransmission/signal transduction)	Inframe deletion of exon 5	
<b>Epithelial neoplasias</b>	Cell Growth & Differentiation, Vol. 6, Issue 9 1185-1191	Tuberous sclerosis gene (signal transduction)	Deletion from amino acids 947 to 990, (deletion of 129-bp exon), inclusion of separate 69-bp exon encoding a novel serine-rich amino acid sequence (1272 to 1295)	
<b>Gastric cancer</b>	Molecular and Cellular Biology, Oct. 1996, p. 5518-5526	Ron (tyrosine kinase receptor/signal transduction)	Joining of 2677 to 2825 (inframe deletion of 147 bp exon)	
<b>Breast and ovarian cancer</b>	Molecular and Cellular Biology, 17:444-452	BRCA1 (DNA repair)	Inframe deletion of exon 11	
<b>Phenylketonuria</b>	J. Biol. Chem 266: 9351- 9354, 1991	Phenylalanine Hydroxylase gene (metabolism)	Deletion of Ile at position 94 or 95	
<b>X-linked agamma- globulinemia</b>	J. Biol. Chem. 271:30303-30306	Bruton's tyrosine kinase (signal transduction)	Deletion of 33 amino acids (amino acid residues 48-80)	

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(immunodeficiency disorder)					
Hereditary elliptocytosis (anemia)	J. Biol. Chem. 266:15154-15159, 1991	Deletion of exon X, out of frame after junction			J05500 [SEQ ID NO: 37]
Osteogenesis imperfecta	J. Biol. Chem. 266, No. 33, Issue of November 25, pp. 22370-22374	Pro- $\alpha$ 1(I) collagen (connective tissue)	Inframe 9 bp (3 amino acid) deletion GPPGA <sup>^</sup> PGAPG [SEQ ID NO: 38]		
Defective apoptosis	J. Biol. Chem. 273:30139-30146	Bcl-2-related ovarian killer (apoptosis regulation)	Deletion of amino acid 76-118 TVLLRLG <sup>^</sup> ITWGKVV [SEQ ID NO: 39]		
Alzheimer's disease	J. Biol. Chem. 267:10804-10809	Beta-A4 amyloid precursor protein (amyloid protein)	Inframe deletion of exon 15		
Alcoholism	J. Biol. Chem. 276: 29764-29771	N-Methyl-D-aspartate R1 (neurotransmission/signal transduction)	Eight isoforms generated by alternative splicing of exons 5, 21, and 22		

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<b>Goodpasture disease (autoimmunity)</b>	J. Biol. Chem. 275: 40392-40399	Goodpasture antigen-binding protein (serine/threonine kinase, signal transduction)	Deletion from 1519-1596 (amino acids 371-396)	AF232930 [SEQ ID NO: 32] (normal) and [SEQ ID NO: 33] (alternative splice form)  AF232935 [SEQ ID NO 34] (alternative splice form partial sequence)
<b>Induction of apoptosis</b>	J Biol Chem. 273:11930-11936	BAX (apoptosis regulation)	Insertion of 49 bp, novel C-terminus: GLPLAESLKRLMSLSPGRPPLLLWDAH VADRDHLCGGSAHRLTHHLEEDGLRP PAALDCVFPP [SEQ ID NO: 35]	
<b>Systemic Lupus Erythematosus</b>	Biochemical and Biophysical Research Communications 272, 877-881	Caspase-8 (apoptosis regulation)	Alternative splicing of intron 8, frameshift after junction (underlined) HLDAGTVEPKREK [SEQ ID NO: 36]	
<b>Diabetes (non insulin dependent diabetes)</b>	Biochemical and Biophysical Research Communications 181:1419-1424	Insulin receptor (receptor/signal transduction)	Alternative splicing of exon 11 resulting in 12 additional amino acids at C-terminus	



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<b>Pelizaeus-Merzbacher Disease</b>	Annals of Neurology 1995, 38, pp. 610-617	DM20 – Myelin Component	Two alternative splice forms of DM20 – Alt 1 is a fragment of 224 bp encompassing nucleotides –20 to +369 in which 162 bp of exon II (from +4 to +166) has been removed, leaving the reading frame intact but substituting Asp for Gly2. Alt 2 is a fragment of 253 bp from –20 to +369 in which 133 bp (from +33 to +166) is spliced out from exon II, shifting the mRNA out of frame after the splice.	[SEQ ID NOS: 40 & 41] (nucleotide sequence of splice junctions)
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<sup>1</sup>The entire disclosure of each journal article is herein incorporated by reference.<sup>2</sup>The entire disclosure of each GenBank record is herein incorporated by reference.

As can be seen from Table 1, certain types of diseases or conditions tend to produce diseased or abnormal cells containing alternative splice forms. For example, alternative splice forms are present in diseased or abnormal cells caused by infections or stress; cancers (*e.g.*, acute promyelocytic leukemia; acute lymphoblastic leukemia; myeloblastic leukemia; uterine cancer; thyroid cancer; gastrointestinal tumors; dysplastic and neoplastic cervical epithelium; melanoma; breast cancer; prostate cancer; lung cancer; endometrial cancer; teratocarcinoma; colon cancer; desmoplastic round cell tumors; epithelial neoplasias; gastric cancer; ovarian cancer); disorders or conditions of the immune system (*e.g.*, allergic response, x-linked agammaglobulinemia, immunity/inflammation, systemic lupus erythematosus, Goodpasture disease); metabolic disorders (*e.g.*, phenylketonuria, non-insulin dependent diabetes); collagen disorders (*e.g.*, osteogenesis imperfecta); disorders of the arteries (atherosclerosis); inherited red cell membrane disorders (*e.g.*, hereditary elliptocytosis); thyroid hormone repression; endometrial hyperplasia; Alzheimer's disease; and alcoholism.

Within a particular type of disease or condition, alternative splice forms tend to be produced from certain genes. For example, in cancer, the CD44 gene; steroid hormone receptors genes (such as the estrogen receptor gene) and the FHIT gene produce a variety of alternative splice forms from which peptides of the invention can be derived.

One of ordinary skill in the art can identify other genes which potentially produce alternative splice forms using well-known techniques, including linkage analysis, gene expression array analysis, homology searches, and point mutation analysis, and commercially available computer software which can be used to predict exon usage in a given nucleic acid sequence.

The mRNA transcribed from genes which are involved in a particular disease process can be analyzed for the presence of alternative splice patterns using techniques well-known in the art. Such techniques include reverse transcription-polymerase chain reactions (RT-PCR), northern blotting and in-situ hybridization. Techniques for analyzing mRNA sequences are described, for example, in Busting SA (2000), *J. Mol. Endocrinol.* 25: 169-193, the entire

disclosure of which is herein incorporated by reference. Representative techniques for identifying alternatively spliced mRNAs are also described below.

For example, databases that contain nucleotide sequences related to a given disease gene can be used to identify alternatively spliced mRNA. Databases which include nucleotide sequences include GenBank, Embase, and the Cancer Genome Anatomy Project (CGAP) database. The CGAP database, for example, contains expressed sequence tags (ESTs) from various types of human cancers. An mRNA or gene sequence can be used to query such a database to determine whether ESTs representing alternatively spliced mRNAs have been found for a particular gene expressed in a given disease state.

A technique called "RNase protection" can also be used to identify alternatively spliced mRNAs. RNase protection involves translation of a gene sequence into synthetic RNA, which is hybridized to RNA derived from diseased or abnormal cells. The hybridized RNA is then incubated with enzymes that recognize RNA:RNA hybrid mismatches. Smaller than expected fragments indicate the presence of alternatively spliced mRNAs. The putative alternatively spliced mRNAs can be cloned and sequenced by methods well known to those skilled in the art.

The technique of reverse transcription coupled with the polymerase chain reaction ("RT-PCR") can also be used to identify alternatively spliced mRNAs. In RT-PCR, mRNA from the diseased tissue is converted into cDNA by the enzyme reverse transcriptase, using methods well-known to those of ordinary skill in the art. The entire coding sequence of the cDNA is then amplified via PCR using a forward primer located in the 3' untranslated region and a reverse primer located in the 5' untranslated region. The amplified products can be analyzed for alternative splice forms, for example by comparing the size of the amplified products with the size of the expected product from normally spliced mRNA. A preferred method of determining the relative size of the amplified products is gel electrophoresis through agarose gels. Any change in the size of the amplified product can indicate alternative splicing.

If the first round of PCR yields an indistinct product band, for example when analyzed by agarose gel electrophoresis, a portion of the initial PCR reaction can be used in second round of amplification. The second round of amplification preferably employs a set of primers that are internal to the first set of primers. This process, called "nested PCR," is well known to those of ordinary skill in the art. If the amplified products still produce an indistinct band on an agarose gel after the second round of amplification, a third round of nested PCR may be performed. Once a distinct band representing the amplification product is produced, the band is excised from the gel, and the DNA is extracted and sequenced according to known techniques (e.g., the dideoxy-chain termination method according to Sanger et al. (1977), *Proc. Natl. Acad. Sci. USA* 74: 5463, the entire disclosure of which is herein incorporated by reference).

Once an alternatively spliced mRNA is identified, the amino acid sequence of all or part of the alternative splice form encoded by the mRNA can be determined by translating the mRNA sequence according to known techniques. The amino acid sequence encoded by the alternatively spliced mRNA can also be predicted from standard codon usage tables. See, e.g., Fig. 9.1 on pg. 214 of Lewin B, *Genes VI*, Oxford University Press, Inc., New York, 1997, the entire disclosure of which is herein incorporated by reference. Peptides based on this sequence can then be generated and used in the practice of the invention.

Nucleic acid sequences from a partially sequenced alternatively spliced mRNA (or nucleic acid sequences derived from a partial amino acid sequence of an alternative splice form) can be used to identify peptides of the invention. For example, a probe or primer can be generated from the partial sequence of an alternatively spliced mRNA or alternative splice form. The probe or primer can be used with known molecular biology techniques such as primer extension, nucleic acid sequencing, or nucleic acid hybridization to obtain additional sequence data with respect to the partially sequenced alternatively spliced mRNA. Peptides of the invention can be synthesized from the additional alternatively spliced mRNA sequences obtained in this manner.

Peptides of the invention must contain at least one amino acid or sequence of amino acids which are not found in the normal protein corresponding to the alternative splice form, or at least one novel juxtaposition of amino acid sequences typically located in different parts of the normal protein. In one embodiment, the peptide of the invention can comprise only amino acid sequences unique to the alternative splice form. Peptides of the invention can be any length, but preferably are between 4 and 50 amino acids in length. Particularly preferred are peptides of the invention which are 7 to 25 amino acids, for example 8 or 9, amino acids in length.

To minimize immunologic cross-reactivity with the corresponding normal protein, it is preferred that the amount of normal amino acid sequence contained in the peptides of the invention is limited. The recognition site for MHC Class I molecules, which are essential for the processing of peptide antigens, is 8 or 9 amino acids in length. Without wishing to be bound by any theory, it is believed that peptides of the invention containing normal amino acid sequences which are 8 or more amino acids in length can generate an unwanted immune response against the normal protein. Therefore, the length of contiguous normal sequence contained within the peptides of the invention is preferably 7 amino acids or less. More preferably, the contiguous normal amino acid sequence is 6, 5, 4, 3, 2 or 1 amino acids in length. It is contemplated that the peptides of the invention can comprise more than one sequence of contiguous normal amino acids.

For peptides of the invention derived from alternative splice forms created by the fusion of ordinarily distant amino acid sequences, it is preferred that the contiguous normal amino acid sequences flanking the splice junction are no more than seven amino acids in length. More preferably, the contiguous normal amino acid sequences flanking the splice junction are each 6, 5, 4, 3, 2 or 1 amino acids in length. In one embodiment, peptides of the invention can comprise contiguous normal amino acid sequences flanking the splice junction of 5 or 6 amino acids in length. Without wishing to be bound by any theory, it is believed that such peptides can produce significantly less cross-reactivity to

the corresponding normal protein, while still having an optimal length for MHC class I antigen presentation.

The peptides of the invention can be prepared by any method for synthesizing peptides. For example, the peptides can be obtained by in vitro translation of the corresponding mRNA. The peptides can also be synthesized in solution or on a solid support in accordance with conventional techniques. Various automatic synthesizers are commercially available and can be used in accordance with known protocols. See, for example, Stewart and Young, *Solid Phase Peptide Synthesis*, 2d. ed., Pierce Chemical Co. (1984); Tam et al., *J. Am. Chem. Soc.* 105:6442, 1983; Merrifield, *Science* 232:341-347, 1986; and Barany and Merrifield, *The Peptides*, Gross & Meienhofer, eds., Academic Press, New York, pp. 1-284 (1979), the entire disclosures of which is incorporated herein by reference.

Alternatively, peptides of the invention can be produced using recombinant DNA technology. For example, nucleic acids encoding the peptides can be synthesized by reverse transcription of the alternatively spliced mRNA, or by chemical synthetic techniques well-known in the art. The nucleic acid coding sequence can then be provided with appropriate linkers and ligated into expression vectors commonly available in the art.

The expression vector can comprise regulatory sequences such as start and stop codons, promoter and terminator regions and an origin of replication. For example, promoter sequences compatible with bacterial hosts can be provided in plasmids containing convenient restriction sites for insertion of the desired coding sequence.

Expression vectors comprising nucleic acids encoding the present immunogenic peptides are preferably transfected into suitable bacterial hosts for expression of the peptides, according to known techniques. Yeast or mammalian cell hosts may also be used, provided the expression vector comprises compatible control sequences. A number of expression vectors and host systems are known in the art, and are commercially available.

Nucleic acids encoding the peptides of the invention can be linked to additional protein coding sequences in an expression vector. Expression of the

linked coding sequences produces a fusion protein comprising the peptide of the invention. The additional coding sequences can comprise sequences which encode other peptides of the invention, or sequences which encode other types of proteins.

5 Other techniques for cloning and expressing nucleic acids are described in, for example, Sambrook et al., *Molecular Cloning, A Laboratory Manual*, Cold Spring Harbor Press, Cold Spring Harbor, N.Y. (1982), and Ausubel et al., (ed.) *Current Protocols in Molecular Biology*, John Wiley and Sons, Inc., New York (1987), and U.S. Pat. Nos. 4,237,224, 4,273,875, 4,431,739, 4,363,877 and  
10 4,428,941, the entire disclosures of which are incorporated herein by reference.

The peptides of the invention can comprise additional amino acids; *i.e.*, amino acids not encoded by the corresponding mRNA. For example, one or more amino acids such as tyrosine, cysteine, lysine, glutamic or aspartic acid can be added to the C- or N-terminus of the peptides. These additional amino  
15 acids can be used for: linking two or more peptides of the invention to each other, for coupling one or more peptides of the invention to a polyvalent platform that can enhance presentation of the peptides to the immune system (*e.g.*, polylysine, polyethylene glycol, and the like), for coupling one or more peptides of the invention to a another protein or other molecule; or for  
20 modifying the physical or chemical properties of the peptides of the invention. Sites for linking the peptides of the invention to a polyvalent platform or to another protein or other molecule can also be introduced by terminal-NH<sub>2</sub> acylation (*e.g.*, acetylation), thioglycolic acid amidation, terminal-carboxy amidation (*e.g.*, with ammonia or methylamine) of the peptides or biotinylation.

25 Preferably, the peptides of the invention are linked together to form homo- or hetero-multimers. The homo- or hetero-multimers can comprise dimers, trimers, tetramers, pentamers, hexamers or higher multimers. It is understood that formation of the peptides of the invention into multimers should not substantially interfere with ability of the linked peptides to function as  
30 desired, *e.g.*, as a cytotoxic T cell determinant or activator of an antibody response.

In a preferred method, homo- or hetero-multimers of the peptides of the invention are formed via cysteine residues which are added to the N- and/or C-terminus of the peptides. The peptides are then formed into multimers via controlled oxidation of the cysteine residues.

5 In another method, a disulfide/amide forming heterobifunctional agent such as N-succidimidyl-3-(2-pyridyl-dithio) proprionate (SPDP) is used to form multimers with the peptides of the invention. For example, the peptides can be linked via formation of a disulfide linkage between a first SPDP functional group and a cysteine residue in one peptide, and formation of an amide linkage  
10 between a second SPDP functional group and free amino group in another peptide. Other suitable disulfide/amide forming heterobifunctional agents are known; see, for example, *Immun. Rev.* 62:185, 1982, the entire disclosure of which is herein incorporated by reference.

Multimers can also be formed from the peptides of the invention using  
15 bifunctional coupling agents that form a thioether linkage. Suitable thioether forming agents are commercially available, and include reactive esters of 6-maleimidocaproic acid; 2 bromoacetic acid; 2-iodoacetic acid; and 4-(N-maleimido-methyl) cyclohexane-1-carboxylic acid. To effect coupling of the peptides, the carboxyl groups of the thioether forming agents are activated with  
20 succinimide or the sodium salt of 1-hydroxy-2-nitro-4-sulfonic acid. A preferred activated thioether coupling agent is succinimidyl 4-(N-maleimidomethyl) cyclohexane-1-carboxylate (SMCC).

It is understood that monomeric or multimeric peptides of the invention can also be linked to other proteins using the techniques and reagents described  
25 above.

The peptides of the invention can also be modified as necessary to provide certain desired attributes such as improved pharmacological or immunologic effects, or to facilitate entry of the peptides into cells.

Modifications which can improve immunologic effects of the peptides of  
30 the invention include modifications which enhance the CTL or antibody-inducing activity. For example, the hydrophobicity of the peptide N-terminus can be increased, particularly where the second residue of the N-terminal is



already hydrophobic and is implicated in binding to an HLA restriction molecule. Without being bound by any theory, it is believed that increasing the hydrophobicity of the N-terminus of the peptides of the invention enhances the efficiency of presentation to T cells. Thus, the peptides of the invention that  
5 contain epitopes for which a host may not generate significant CTL activity can be made CTL-inducing by substituting hydrophobic residues at the N-terminus of the peptide.

Other modifications which improve the immunologic effects of the peptides of the invention include amino acid insertions, deletions, and  
10 substitutions (either conservative or non-conservative) which increase the binding affinity of the immunogenic peptide to an MHC molecule for subsequent presentation to a cytotoxic T-lymphocyte. By "conservative substitutions" is meant replacing an amino acid residue with another that is biologically and/or chemically similar; *e.g.*, one hydrophobic residue for  
15 another, or one polar residue for another. Combinations of amino acids which are biologically or chemically similar include Gly/Ala; Val/Ile/Leu; Asp/Glu; Asn/Gln; Ser/Thr; Lys/Arg; and Phe/Tyr.

Factors which influence the number and type of amino acid residues that can be substituted or deleted include the spacing between essential epitopic  
20 points on the immunogenic peptide, and certain conformational and functional attributes that may be sought (*e.g.*, hydrophobicity vs. hydrophilicity). Replacing one amino acid with another in a given combination would therefore be a conservative substitution. Other conservative substitutions will be apparent to those of ordinary skill in the art.

25 In addition, the contributions made by the side chains of amino acid residues in the peptides of the invention can be probed via systematic replacement of amino acid residues in the peptide with a specified amino acid (*e.g.*, Ala).

The peptides of the invention can also be modified to increase stability  
30 of the peptides, either *in vitro* or *in vivo*. Such modifications include synthesizing the peptides to contain at least one D-amino acid. The D-amino acid containing peptides are more resistant to peptidases and are more stable in

serum and tissues compared to their L-peptide counterparts. It is expected that peptides of the invention synthesized as D-amino acid containing peptides will have the same efficacy as the corresponding L-peptide. However, any loss of binding affinity for an MHC molecule would be compensated for by increased  
5 *in vivo* stability of the D-amino acid peptide. Stability of an L-amino acid-containing peptide of the invention can also be increased by "capping" the peptide with a D-amino acid, which inhibits exopeptidase destruction of the peptide. D-amino acid containing peptides can also be synthesized as "inverso" or "retro-inverso" forms; that is, by replacing all L-amino acids of a sequence  
10 with D-amino acids, or by reversing the sequence of the amino acids and replacing all the L-amino acids with D-amino acids.

Modifications of the peptides of the invention which do not affect the ability of the peptides of the invention to elicit an immune response are also contemplated. For example, amino acid residues which are not required for  
15 retention of immunogenic activity can be substituted or deleted. One of ordinary skill in the art can readily determine which amino acids can be substituted or deleted, for example by mutational analysis techniques well-known in the art. Generally, any substitutions, additions or deletions between epitopic and/or conformationally important residues will employ amino acids or  
20 moieties chosen to avoid steric and charge interference that might disrupt binding of the peptide to an MHC molecule. Other types of modifications which do not affect the ability of the peptides of the invention to elicit an immune response are discussed *supra* under the definition of "protein" or "peptide."

25 One or more peptides of the invention can be administered to a subject to stimulate an immunologic response against the alternative splice form from which the peptides were derived. The immunologic response stimulated by the peptides includes a cytotoxic T lymphocyte and/or an antibody response. For example, administration of the peptides of the invention can generate an MHC  
30 HLA-class I restricted cytotoxic T lymphocyte response, which includes a CD8<sup>+</sup> T lymphocyte response specific for a target antigen, wherein CD8<sup>+</sup>, MHC class I-restricted T lymphocytes are activated. Administration of the peptides of the

invention can also generate an MHC HLA-class II restricted cytotoxic T lymphocyte response, which includes a CD4<sup>+</sup> T lymphocyte response specific for a target antigen, wherein CD4<sup>+</sup>, MHC class II-restricted T lymphocytes are activated.

5           As used herein, "subject" includes an animal, preferably a mammal, more preferably a human being, that has or is at risk for having a disease or condition in which diseased or abnormal cells produce the alternative splice form from which immunogenic peptide is derived. The alternative splice form from which the peptide of the invention is derived is substantially absent from  
10 normal cells in the subject. Generation of an immunologic response in the host with the peptides results in the prophylactic or therapeutic treatment of the disease or condition associated with the expression of the alternative splice form.

          Preferably, two or more of the peptides of the invention are administered  
15 to the subject. For example, two or more peptides can be used which define different epitopes from one or more alternative splice forms. The two or more peptides can be linked to form multimers by the techniques described above, or can be formulated in a composition without forming multimers; *e.g.*, as an admixture. Admixtures of different multimers, or admixtures of multimers and  
20 monomeric peptides, are also part of the invention. It is contemplated that admixtures can comprise 1, 2, 3, 4 or 5 or more different monomeric or multimeric peptides of the invention.

          When one type of peptide of the invention is administered as a homomultimer, a plurality of repeating epitopes are presented to the subject's  
25 immune system. If two or more different peptides of the invention are administered, either as a heteromultimer or an admixture of peptides, a plurality of heterogeneous epitopes are presented to the subject's immune system. The presentation of a plurality of homo- or heterogeneous epitopes produces a synergistic effect on the subject's immune system. Thus, the immune response  
30 which is generated by administering the peptides of the invention as multimers or admixtures is greater than the expected additive effects of each peptide comprising the multimer or admixture.

The peptides of the invention can also be administered to a subject in combination with other peptides that present "T-helper" cell epitopes; *i.e.*, epitopes that stimulate T cells which cooperate in the induction of cytotoxic T cells against the target antigen. Peptides that present "T-helper" cell epitopes are described in Ferrari et al., *J. Clin. Invest.* 88:214-222, 1991, and U.S. Pat. No. 4,882,145, the entire disclosures of which are herein incorporated by reference.

As used herein, a substance which is administered "in combination with" a peptide of the invention can be administered at the same time and in the same site as the peptide (*i.e.*, as a complex or as an admixture), or can be administered at a different time and/or place as the peptide. For example, the substance can be administered in the same site before or after administration of a peptide of the invention, or can be administered simultaneously with a peptide of the invention but in a distant site (*e.g.*, the substance can be administered orally if the peptide is administered parenterally, and vice versa; or the substance can be administered in a contralateral limb if both peptide and the substance are administered parenterally). As used herein, a substance which is "complexed" with a of the invention peptide can be covalently or noncovalently attached to the peptide.

The peptides of the invention can also be administered to a subject in combination with at least one component that primes CTLs. For example, certain lipids are known to prime CTLs *in vivo* against viral antigens. Lipids suitable for priming CTLs include tripalmitoyl-S-glycerylcysteinyl-seryl-serine (P<sub>3</sub>CSS), which can effectively prime virus-specific cytotoxic T lymphocytes when covalently attached to a peptide. See Deres et al., *Nature* 342:561-564, 1989, the entire disclosure of which is herein incorporated by reference. In a preferred embodiment, peptides of the invention are complexed to P<sub>3</sub>CSS and the resulting lipopeptide is administered to an subject to specifically prime a cytotoxic T lymphocyte response.

The induction of neutralizing antibodies can also be primed with P<sub>3</sub>CSS conjugated to a peptide. Thus, peptides of the invention coupled to P<sub>3</sub>CSS can also elicit a humoral immune response.

In the practice of the invention, at least one peptide of the invention is administered to a patient in an amount sufficient to elicit an immune response; *i.e.*, an antibody or cytotoxic T lymphocyte response, to the diseased or abnormal cells (the "effective amount"). Where peptides of the invention are administered as a multimer or as an admixture, the effective amount represents the cumulative total of the administered peptides. The presence of an immune response in the subject can be determined, for example, by measuring antigen-specific CTL activity in peripheral blood lymphocytes (PBLs) obtained from the subject during treatment. Alternatively, the presence of an immune response in the subject can be determined by measuring the titer of antibodies specific to the peptides of the invention, or by intradermal injection of the peptides of the invention with subsequent measurement of a delayed-type hypersensitivity (DTH) response.

The effective amount of the peptides of the invention administered to a given subject will depend on factors such as the peptide composition, the manner of administration, the stage and severity of the disease being treated, the weight and general state of health of the subject, and the judgment of the prescribing physician. Generally, an effective amount of the peptides of the invention administered to a 70 kg subject is from about 1 microgram to about 2,000 mg of peptide, preferably about 1 microgram to about 500 mg of peptide, more preferably about 10 micrograms to about 200 mg of peptide, and particularly preferably about 50 micrograms to about 100 mg peptide. An optimal dose is about 500 micrograms of peptide/70 kg subject.

It is understood that the peptides of the invention are often employed in serious disease states; that is, situations where the subject's life is threatened. In such cases, particularly in view of the relatively nontoxic nature of the immunogenic peptides, it is possible to administer substantial excesses of the peptides to the subject; *i.e.*, effective amounts in excess of 2000 mg/70 kg subject.

Single or multiple administrations of an effective amount of the peptides of the invention can be performed with dose levels and patterns selected by the treating physician. For therapeutic use, an initial dose of the peptides is

preferably administered to a subject at the first appearance of clinical symptoms, or shortly after diagnosis of the disease or condition, with "booster doses" administered until at least a partial abatement of symptoms is observed. A preferred dosage regimen for therapeutic treatment comprises administering to a  
5 subject an initial dose of from about 10 micrograms to about 100 mg of at least one peptide of the invention, followed by booster dosages every 2-4 weeks of from about 1 microgram to about 1 mg of at least one peptides of the invention for a period of 6 weeks to 3 months, depending on the strength of the subject's immune response or degree of response to the treatment. Other therapeutic  
10 dosage regimens are contemplated.

For prophylactic use, an effective amount of at least one peptide of the invention is preferably administered in uniform doses at regular intervals over a period of weeks or months. A preferred dosage regimen for prophylactic use is administration of about 10 micrograms to about 100 mg of at least one peptide  
15 of the invention every 2-4 weeks for 6 to 8 months. Other prophylactic dosage regimens are contemplated.

For therapeutic or prophylactic use, the peptides of the invention can be administered by any route which is sufficient to expose the peptides to the subject's immune system. Routes of administration include enteral (*e.g.*, oral, rectal, intranasal, etc.) and parenteral administration. Parenteral administration  
20 includes intravenous, intramuscular, intraarterial, intraperitoneal, intravaginal, intravesical (*e.g.*, into the bladder), intradermal, intrapulmonary, inhalation, topical or subcutaneous administration. Also contemplated within the scope of the invention is the instillation of the peptides into the body of the subject in a  
25 controlled formulation, with systemic or local release of the peptides to occur at a later time. Preferred routes of administration are via intramuscular, intranasal, intradermal and subcutaneous delivery.

For therapeutic or prophylactic treatment, at least one peptide of the invention can also be administered to a subject via expression of nucleic acid  
30 sequences encoding the peptide in cells of the subject. For example, cells of a subject can be infected with an attenuated viral host engineered to express at least one nucleic acid encoding a peptide of the invention. A preferred

attenuated viral host is vaccinia virus. In the practice of the invention, an attenuated viral host comprising nucleic acid sequences encoding one or more of the peptides of the invention is introduced into a subject such that some of the subject's cells are infected with the viral host. The infected cells, under control  
5 of the viral host, express the peptides of the invention and elicit an immune response in the subject; *i.e.*, a cytotoxic T lymphocyte or antibody response. Vaccinia viral vectors useful as attenuated viral hosts, and methods for delivering the vectors to a subject are known in the art, for example as described in U.S. Pat. No. 4,722,848, the entire disclosure of which is herein incorporated  
10 by reference.

For therapeutic or prophylactic treatment, the peptides of the invention can also be administered to a subject via expression of nucleic acid sequences encoding the peptide in bacterial hosts. In the practice of the invention, a bacterial host comprising one or more nucleic acid sequences encoding a  
15 peptide of the invention are introduced into a subject, for example by intradermal or intravesical instillation. The bacterial host expresses the peptides of the invention, and elicits an immune response in the subject; *i.e.*, a cytotoxic T lymphocyte or antibody response. A preferred bacterial host is bacillus Calmette Guerin (BCG), which is described in Stover et al. (Nature 351:456-  
20 460, 1991), the entire disclosure of which is herein incorporated by reference. Other bacterial hosts suitable for use in the practice of the invention, such as *Salmonella typhi*, *Listeria monocytogenes* and the like, are known to those skilled in the art.

For therapeutic or prophylactic treatment, the peptides of the invention  
25 can also be administered to a subject via expression of nucleic acid sequences encoding the peptide in yeast hosts. In the practice of the invention, a yeast host comprising one or more nucleic acid sequences encoding a peptide of the invention are introduced into a subject, for example orally, or by intradermal or intravesical instillation. The yeast host expresses the peptides of the invention,  
30 and elicits an immune response in the subject; *i.e.*, a cytotoxic T lymphocyte or antibody response. Preferred yeast hosts are *Saccharomyces cerevisiae* or *Schizosaccharomyces pombe*.

The peptides of the invention can be administered to a subject in combination with any known carrier or adjuvant. Suitable carriers include keyhole limpet hemocyanin; thyroglobulin; albumins such as human serum albumin; tetanus toxoid; polyamino acids such as poly(D-lysine:D-glutamic acid), and the like. Suitable adjuvants include complete or incomplete Freund's adjuvant, aluminum phosphate, aluminum hydroxide, polylecithins, emulsified oils and alum.

The peptides of the invention can also be administered to a subject in combination with immunostimulatory compounds. For example, the immunogenic peptides can be administered with granulocyte macrophage colony stimulating factor (GM-CSF), which is a cytokine known to enhance the presentation of peptides to dendritic cells for processing and presentation to the immune system. Other suitable immunostimulatory molecules include other cytokines such as IL-12, IL-2, IL-4, IL-5, IL-1alpha, and IL-18; and haptens such as dinitrophenol.

The peptides of the invention can also be administered to a subject by exposing immune system effector cells from a subject to one or more of the peptides *ex vivo*. As used herein, "immune system effector cells" are cells which either prime the immune system to target other cells for elimination, or which effect elimination of targeted cells (*i.e.*, "killer" cells). Immune system effector cells include dendritic cells, lymphokine-activated killer (LAK) cells, natural killer (NK) cells, T-cells and macrophages. Methods of obtaining immune system effector cells, and methods for *ex vivo* treatment of such cells are known in the art, for example as described in Blaese *et al.*, 1995, *Science* 270:475-80; Kohn *et al.*, 1995, *Nature Medicine* 1(10):1017-23; and Ferrari *et al.*, 1992, *Blood* 80:1120-24, the entire disclosures of which are herein incorporated by reference.

For example, immune system cells, or mixtures thereof, can be removed from a subject and maintained in culture. The immune system effector cells can optionally be enriched for a particular cell type, either in culture or upon removal from the subject. The cultured immune system cells are then treated with the immunogenic peptides. Treatment of the cells with peptides of the



invention includes direct exposure of the cells to the peptides, or introduction of a nucleic acid encoding the peptides into the cells. For cells directly exposed to the peptides of the invention, concentrations far in excess of what could be tolerated by a subject if administered *in vivo* can be used. For example, cells  
5 can be treated with a 10 micromolar solution of the peptides of the invention, or can be treated with peptides of the invention in a final concentration of about 5 mg/ml to about 10 mg/ml, preferably about 0.1 ng/ml to about 5 mg/ml.

Immune system effector cells are generally capable of internalizing the peptides of the invention upon direct exposure to the peptides in culture.  
10 However, the peptides of the invention can be modified so that entry into the immune system effector cells is enhanced. For example, the peptides can be encapsulated in a liposome prior to being administered, as is described in more detail below. The encapsulated peptides are delivered directly into the cells by fusion of the liposome to the cell membrane. Reagents and techniques for  
15 encapsulating the peptides of the invention in liposomes are well-known in the art, and include, for example, the ProVectin™ Protein Delivery Reagent from Imgenex.

The peptides of the invention can also be modified to enhance entry into the cells by complexing the peptides with a peptide leader sequence known as a  
20 “protein transduction domain” or “PTD.” PTDs direct entry of the compound into cells by a process known as “protein transduction.” *See* Schwarze et al. (1999), *Science* 285: 1569 – 1572. PTDs are well-known in the art, and may comprise any of the known PTD sequences including, for example, arginine-rich sequences such as a peptide of nine to eleven arginine residues optionally in  
25 combination with one to two lysines or glutamines as described in Guis et al. (1999), *Cancer Res.* 59: 2577-2580, the entire disclosure of which is herein incorporated by reference. Preferred PTDs are sequences of eleven arginine residues or the NH<sub>2</sub>-terminal 11-amino acid protein transduction domain from the human immunodeficiency virus TAT protein (SEQ ID NO: 42). Other  
30 suitable PTD sequences include other arginine-rich sequences; *e.g.*, 9 or 10 arginines, or six or more arginines in combination with one or more lysines or glutamines. Such leader sequences are known in the art; *see, e.g.*, Guis et al.

(1999), *supra*. A PTD may be located anywhere on the peptides of the invention that does not disrupt the peptides' ability to elicit an immune response, but is preferably located at the C-terminal end.

5       Kits and methods for constructing fusion proteins comprising a peptide of the invention and a PTD are known in the art; for example the TransVector™ system (Q-BIOgene), which employs a 16 amino acid peptide called "Penetratin™" corresponding to the *Drosophila* antennapedia DNA-binding domain; and the Voyager system (Invitrogen Life Technologies), which uses the 38 kDa VP22 protein from Herpes Simplex Virus-1.

10       The peptides of the invention can also be modified to enhance entry into cells by complexing the peptides with heat shock proteins (HSP), for example as described in US Pat. No. 5,935,576 of Srivastava (peptide non-covalently linked to HSP), or Suzue K et al. (1997), *Proc. Natl. Acad. Sci. USA*, 94:13146-13151 (peptide covalently linked to HSP), the entire disclosures of which are herein  
15       incorporated by reference. Fusion proteins comprising HSP sequences and a peptide of the invention can also be generated according to standard techniques.

20       A nucleic acid encoding a peptide of the invention can be introduced into the immune system effector cells by any known method, for example by transfecting the cells with expression vectors or infecting the cells with an attenuated viral host as described above. Techniques for constructing expression vectors comprising nucleic acid sequences encoding peptides of the invention are discussed above.

25       After treatment with at least one peptide of the invention, a portion of the *ex-vivo* treated immune system effector cells can be examined to confirm the presence of appropriate levels of the peptide(s) within the cell, and the remaining treated cells can be reintroduced into the subject. Treated cells may be reintroduced into the subject by parenteral methods, including intravenous infusion and direct injection into the bone marrow. Treated cells are preferably reintroduced into the subject in a saline solution or other pharmaceutically  
30       acceptable carrier. The number of treated cells to be reintroduced depends on the purity of the cell population, but a typical dosage is in the range of about  $10^5$  to about  $10^8$  cells per kilogram of subject body weight. The number of cells

available for re-introduction can be increased by expanding the cells in culture prior to treatment with the peptides of the invention.

The invention also provides a method for identifying peptides of the invention which induce MHC-restricted cytotoxic T lymphocyte responses. For example, peripheral blood lymphocytes (PBLs) can be obtained and exposed to one or more peptides of the invention. The ability of the peptides to induce specific cytotoxic activity is determined by incubating the stimulated PBL with autologous labeled (e.g.,  $^{51}\text{Cr}$ ) target cells (such as HLA matched macrophages, T cells, fibroblasts or B lymphoblastoid cells) that endogenously synthesize the targeted antigen (or, alternatively, the cell is pulsed with the peptide of interest), and measuring specific release of label. Preferably, the PBLs are exposed to pools of peptides of the invention, wherein each peptide is about 8 to 20 amino acids long, preferably 9 to 12 amino acids long. Peptides of the invention which induce cytotoxic T lymphocyte activity can be selected from the pools.

Once an peptide of the invention that stimulates a cytotoxic T lymphocyte response is identified, the MHC restriction element of the response can be determined. This involves incubating the stimulated PBL (or short term cultures thereof) with a panel of labeled target cells of known HLA types that have been pulsed with the peptide of interest or the appropriate controls. The HLA allele(s) of cells that are lysed by the stimulated PBL are compared to cells not lysed. The HLA alleles from the lysed target cells represent the MHC restriction element(s) for the cytotoxic T lymphocyte response to the peptide.

The lysis of target cells by stimulated PBLs can be detected either by measuring the release of label from autologously labeled target cells, or with an enzyme-linked immunospot ("ELISPOT") assay. The ELISPOT method is well-known in the art, and kits and reagents for performing the method are commercially available from BD Biosciences Pharmingen, San Jose, CA, 95131-1807. An ELISPOT assay can detect cytokine release from a PBL at the single cell level, allowing the direct determination of cytokine-producing cell frequencies.

Briefly, the ELISPOT method is performed by coating a cell culture dish or well with a cytokine capture antibody, for example an anti-interferon gamma

antibody. The unoccupied spots on the culture dish or well are then blocked with a non-specific binding protein. Target cells, for example tumor cells, that endogenously synthesize the alternative splice form which has been used to stimulate PBLs are added to the culture dish or well. Alternatively, target cells  
5 can be pulsed with the peptide of interest. Activated PBLs are then added to the culture dish or well. If the activated PBLs specifically lyse the target cells, the PBLs secrete cytokines such as interferon-gamma, which is captured by the cytokine capture antibody initially coated onto the culture dish or well. A secondary antibody that recognized a different epitope of interferon gamma is  
10 then used to detect the presence of any interferon-gamma secreted by the PBLs and captured by the cytokine capture antibody. The secondary antibody can be conjugated with a detectable label, such as fluorescent or radioactive label. Identification of peptides of the invention which induce MHC-restricted cytotoxic T lymphocyte responses by the ELISPOT method is shown in  
15 Example 5 below.

The peptides of the invention can be formulated into pharmaceutical compositions, also called vaccine compositions, according to techniques known in the art. Pharmaceutical compositions of the present invention are characterized as being at least sterile and pyrogen-free. As used herein,  
20 "pharmaceutical formulations" include formulations for human and veterinary use. The present pharmaceutical formulations may comprise at least one peptide of the invention mixed with a physiologically acceptable carrier medium to form solutions, suspensions or dispersions. Preferred physiologically acceptable carrier media are water, buffered water, normal saline, 0.4% saline, 0.3%  
25 glycine, hyaluronic acid and the like.

Pharmaceutical compositions of the invention can also comprise conventional pharmaceutical excipients and/or additives. Suitable pharmaceutical excipients include stabilizers, antioxidants, osmolality adjusting agents, buffers, and pH adjusting agents. Suitable additives include  
30 physiologically biocompatible buffers (e.g., tromethamine hydrochloride), additions (e.g., 0.01 to 10 mole percent) of chelants (such as, for example, DTPA or DTPA-bisamide) or calcium chelate complexes (as for example

calcium DTPA, CaNaDTPA-bisamide), or, optionally, additions (e.g., 1 to 50 mole percent) of calcium or sodium salts (for example, calcium chloride, calcium ascorbate, calcium gluconate or calcium lactate). Pharmaceutical compositions of the invention can be packaged for use in liquid form, or can be  
5 lyophilized.

For solid compositions, conventional nontoxic solid carriers can be used; for example, pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharin, talcum, cellulose, glucose, sucrose, magnesium carbonate, and the like.

10 Methods for preparing pharmaceutical compounds of the invention are known to those of ordinary skill in the art, for example as described in *Remington's Pharmaceutical Science*, 17th ed., Mack Publishing Company, Easton, Pa. (1985), the entire disclosure of which is herein incorporated by reference.

15 For example, a solid pharmaceutical composition for oral administration can comprise any of the carriers and excipients listed above and 10-95%, preferably 25%-75%, of one or more peptides of the invention. A pharmaceutical composition for aerosol administration can comprise 0.01-20% by weight, preferably 1%-10% by weight, of one or more peptides of the  
20 invention in finely divided form along with a surfactant and propellant. Suitable surfactants include esters or partial esters of fatty acids containing from 6 to 22 carbon atoms (e.g., caproic, octanoic, lauric, palmitic, stearic, linoleic, linolenic, olesteric or oleic acid with an aliphatic polyhydric alcohol, or its cyclic anhydride); and mixed esters such as mixed or natural glycerides. The  
25 surfactant can comprise 0.1%-20% by weight, preferably 0.25-5% by weight, of the aerosol pharmaceutical composition, with the balance being propellant. A carrier may also be included as desired; e.g., lecithin for intranasal delivery.

The peptides of the invention or pharmaceutical compositions of the invention can be encapsulated in liposomes. Liposomes aid in the delivery of  
30 the immunogenic peptides to a particular tissue, such as lymphoid tissue, and can also increase the blood half-life of the peptides or compositions. Liposomes suitable for use in the invention are formed from standard vesicle-forming

lipids, which generally include neutral or negatively charged phospholipids and a sterol, such as cholesterol. The selection of lipids is generally guided by consideration of factors such as the desired liposome size and half-life of the liposomes in the blood stream. A variety of methods are known for preparing liposomes, for example as described in Szoka et al., *Ann. Rev. Biophys. Bioeng.* 9:467, 1980; U.S. Pat. Nos. 4,235,871, 4,501,728, 4,837,028, and 5,019,369, the entire disclosures of which are herein incorporated by reference. Preferably, peptides of the invention are incorporated as part of a liposome, either alone or in conjunction with a ligand molecule that can target the liposome to a particular cell or tissue. Ligands which bind to receptors prevalent in lymphoid cells, such as monoclonal antibodies that bind to the CD45 antigen, are preferred.

The present invention also provides antibodies against alternative splice forms or peptides of the invention. An antibody of the invention specifically binds an epitope of the alternative splice form or peptide of the invention that is not present in the normal protein. The antibody can be a monoclonal antibody, a polyclonal antibody or an antibody fragment that is capable of binding antigen. The antibodies of the invention include chimeric, single chain, and humanized antibodies, as well as Fab fragments and the products of an Fab expression library. Antibody fragments, such as Fab antibody fragments, which retain some ability to selectively bind to the antigen of the antibody from which they are derived, can be made using well known methods in the art. Such methods are generally described in U.S. patent 5,876,997, the entire disclosure of which is incorporated herein by reference.

Polyclonal antibodies of the invention can be produced by immunizing a host with substantially pure alternative splice form or peptide of the invention, using techniques well-known in the art. The antibody titer in the immunized host can be monitored over time by standard techniques, such as with an enzyme linked immunosorbent assay (ELISA) using immobilized peptide. If desired, the antibody molecules can be harvested or isolated from the host (*e.g.*, from the blood or serum) and further purified by known techniques, such as protein A chromatography to obtain the IgG fraction.

At an appropriate time after immunization, *e.g.*, when the specific antibody titers are highest, antibody-producing cells can be obtained from the host and used to prepare monoclonal antibodies by standard techniques, such as the hybridoma techniques described by Kohler and Milstein (1975) *Nature* 256:495-497 and by Mishell, B.B. et al., Selected Methods In Cellular Immunology, (Freeman WH, ed.) San Francisco, 1980; the human B cell hybridoma technique (Kozbor et al. (1983) *Immunol. Today* 4:72); the EBV-hybridoma technique (Cole et al. (1985), Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, Inc., pp. 77-96); or trioma techniques. See also Current Protocols in Immunology (1994) Coligan et al. (eds.) John Wiley & Sons, Inc., New York, N.Y.). The disclosures of all citations in this paragraph are herein incorporated by reference in their entirety.

Hybridoma cells producing a monoclonal antibody of the invention can be detected by screening the hybridoma culture supernatants for antibodies that bind the polypeptide of interest, *e.g.*, using a standard ELISA assay. Alternatively, a monoclonal antibody directed against an alternative splice form or peptide of the invention can be identified and isolated by screening a recombinant combinatorial immunoglobulin library (*e.g.*, an antibody phage display library) with the peptide of interest. Kits for generating and screening phage display libraries are commercially available (*e.g.*, the Pharmacia Recombinant Phage Antibody System, Catalog No. 27-9400-01; and the Stratagene SurfZAP Phage Display Kit, Catalog No. 240612). Additionally, methods and reagents suitable for generating and screening an antibody display library can be found in, for example, U.S. Pat. No. 5,223,409; PCT Publication No. WO 92/18619; PCT Publication No. WO 91/17271; PCT Publication No. WO 92/20791; PCT Publication No. WO 92/15679; PCT Publication No. WO 93/01288; PCT Publication No. WO 92/01047; PCT Publication No. WO 92/09690; PCT Publication No. WO 90/02809; Fuchs et al. (1991) *Bio/Technology* 9:1370-1372; Hay et al. (1992) *Hum. Antibod. Hybridomas* 3:81-85; Huse et al. (1989) *Science* 246:1275-1281; Griffiths et al. (1993) *EMBO J.* 12:725-734, the entire disclosures of which are herein incorporated by reference.

Recombinant antibodies, such as chimeric and/or humanized monoclonal antibodies, are within the scope of the invention. Such chimeric and humanized (including chimeric humanized) monoclonal antibodies can be produced by recombinant DNA techniques known in the art, for example using methods  
5 described in U.S. Pat. No. 5,225,539; PCT Publication No. WO 87/02671; European Patent Application 184,187; European Patent Application 171,496; European Patent Application 173,494; PCT Publication No. WO 86/01533; U.S. Pat. No. 4,816,567; European Patent Application 125,023; Better et al. (1988) *Science* 240:1041-1043; Liu et al. (1987) *Proc. Natl. Acad. Sci. USA* 84:3439-  
10 3443; Liu et al. (1987) *J. Immunol.* 139:3521-3526; Sun et al. (1987) *Proc. Natl. Acad. Sci. USA* 84:214-218; Nishimura et al. (1987) *Cancer Res.* 47:999-1005; Wood et al. (1985) *Nature* 314:446-449; Shaw et al. (1988) *J. Natl. Cancer Inst.* 80:1553-1559; Morrison (1985) *Science* 229:1202-1207; Oi et al. (1986) *Bio/Techniques* 4:214; Jones et al. (1986) *Nature* 321:552-525; Verhoeyan et al.  
15 (1988) *Science* 239:1534; and Beidler et al. (1988) *J. Immunol.* 141:4053-4060, the entire disclosures of which are herein incorporated by reference.

The present antibodies can be used to isolate peptides of the invention, or the alternative splice forms from which they are derived, using standard techniques such as affinity chromatography or immunoprecipitation. Moreover,  
20 the present antibodies can be used to detect alternative splice forms (*e.g.*, in a cellular lysate or cell supernatant) in order to evaluate the abundance and pattern of expression of an alternative splice form.

The present antibodies can also be used diagnostically to monitor protein levels in tissue as part of a clinical testing procedure, for example to determine  
25 the efficacy of a given treatment regimen. Detection of protein levels with the present antibodies can be facilitated by coupling the antibody to a detectable substance. Suitable detectable substances include various enzymes (*e.g.*, horseradish peroxidase; alkaline phosphatase; beta-galactosidase; and acetylcholinesterase) prosthetic group complexes (*e.g.*, streptavidin/biotin and  
30 avidin/biotin), fluorescent materials (*e.g.*, umbelliferone; fluorescein; fluorescein isothiocyanate; rhodamine; dichlorotriazinylamine fluorescein; dansyl chloride; and phycoerythrin, luminescent materials (*e.g.*, luminol),



bioluminescent materials (*e.g.*, luciferase, luciferin, and aequorin), and radioactive materials (*e.g.*,  $^{125}\text{I}$ ,  $^{131}\text{I}$ ,  $^{35}\text{S}$  or  $^3\text{H}$ ).

Antibodies of the invention can also be used in the therapeutic or prophylactic treatment of subjects having a disease or condition in which diseased or abnormal cells produce an alternative splice form having epitopes to which the antibody can bind. The alternative splice form is substantially absent from normal cells in the subject. In the practice of the invention, an effective amount of at least one antibody of the invention is administered to a subject. Preferably, at least one monoclonal antibody specific for an alternative splice form or peptide of the invention are administered to the subject.

An “effective amount” of the present antibodies is the amount which ameliorates one or more clinical symptoms in a subject, or causes a reduction in the number of diseased or abnormal cells in a subject. Amelioration of clinical symptoms would be readily apparent to the ordinarily skilled physician. The number of diseased or abnormal cells in a subject’s body can also be readily determined. Suitable techniques for determining the number of diseased or abnormal cells includes direct measurement (*e.g.*, calculating the concentration of leukemic cells in the blood or bone marrow) or by estimation from the size of a tissue mass. As used herein, a “tissue mass” is any localized collection of diseased or abnormal cells in a subject’s body, for example a tumor. The size of a tissue mass can be ascertained by direct visual observation or by diagnostic imaging methods such as X-ray, magnetic resonance imaging, ultrasound, and scintigraphy. Diagnostic imaging methods used to ascertain size of a tissue mass can be employed with or without contrast agents, as is known in the art. The size of a tissue mass can also be ascertained by physical means, such as palpation of the tissue mass or measurement of the tissue mass with a measuring instrument such as a caliper. An effective amount of the present antibodies can be, for example, from about 0.1 mg/kg to about 100 mg/kg of body weight, preferably about 50 mg/kg to about 100 mg/kg of body weight, more preferably about 10 mg/kg to about 20 mg/kg of body weight.

The antibodies of the invention are preferably administered to a subject by parenteral means, for example by intravascular (*e.g.*, intraarterial or intravenous) injection or infusion.

- 5           The following examples are offered by way of illustration, not by way of limitation.

**Example 1 - Identification of VEGF Immunogenic peptides**

Alternative splice forms of vascular endothelial growth factor (VEGF)  
10   proteins were identified in HC2 20d2/c cells, which are NIH-3T3 cells that have  
been transfected with a constitutively active form of the EGF receptor,  
EGFRvIII. HC2 20d2/c cells were cultured according to standard techniques.  
Total RNA from HC2 20d2/c cells was isolated, followed by isolation of poly  
A+ RNA. The poly A+ RNA was used as a template for first strand cDNA  
15   synthesis using oligo dT primers. PCR was then performed with primers from  
VEGF isoforms. The sequences of the primers used for the PCR are provided  
below. The primers are represented in the 5' to 3' direction, with nucleotide  
numbers corresponding to the normal cDNA sequence listed to the left of each  
primer, where available.

20

Mouse VEGF

Set 1

79-99           CCG AAA CCA TGA ACT TTC TGC (SEQ ID NO: 43)

936-916       CTT GGC GAT TTA GCA GCA GAT (SEQ ID NO: 44)

25

Set 2

117-137       ACC CTG GCT TTA CTG CTG TAC (SEQ ID NO: 45)

909-888       AAA TGG CGA ATC CAG TCC CAC (SEQ ID NO: 46)

	Set 3		
	126-146	TTA CTG CTG TAC CTC CAC CAT (SEQ ID NO: 47)	
	815-795	GAA GGA TCT CCT CTT CCT TCA (SEQ ID NO: 48)	
5	Murine VEGFB:		
	Set 1		
	119-139	CTG CTT GTT GCA CTG CTG CAG (SEQ ID NO: 49)	
	778-758	TCT GGA AAG CAG CTT GTC ACT (SEQ ID NO: 50)	
10	Set 2		
	155-175	GCC CCT GTG TCC CAG TTT GAT (SEQ ID NO: 51)	
	739-719	TAC AGG TGA CTG GGT TGA GCT (SEQ ID NO: 52)	
	Set 3		
15	182-202	AGC CAC CAG AAG AAA GTG GTG (SEQ ID NO: 53)	
	733-713	TGT CTG GGT TGA GCT CTA AGC (SEQ ID NO: 54)	
	Murine VEGFC:		
20	Set 1		
	151-171	AAC ATG CAC TTG CTG TGC TTC (SEQ ID NO: 55)	
	1559-1539	CTC TCC CGC AGT AAT CCA CAT (SEQ ID NO: 56)	
	Set 2		
25	292-312	GAG GTC AAG GCT TTT GAA GGC (SEQ ID NO: 57)	
	1521-1501	CTT GGG CCT CTG TTA CCA TGT (SEQ ID NO: 58)	
	Set 3		
	301-321	GCT TTT GAA GGC AAA GAC CTG (SEQ ID NO: 59)	
30	1509-1489	TTA CCA TGT GGT CCC ACA GAG (SEQ ID NO: 60)	

## Murine VEGFD:

## Set 1

5      15-35      GGA GAA TGC CTT TTG CAA CAC (SEQ ID NO: 61)  
       1343-1323      GCC ATT GCA TGG AAA TGT GGC (SEQ ID NO: 62)

## Set 2

10      57-77      CAA CTG CTT AGT CAT CGG TAG (SEQ ID NO: 63)  
       1234-1214      ACT TGA CAA AGC AGT GAG CTG (SEQ ID NO: 64)

## Set 3

15      96-116      ATG TAT GGA GAA TGG GGA ATG (SEQ ID NO: 65)  
       1178-1158      GTT GAA TCA AGG GTT CTC CTG (SEQ ID NO: 66)

## Murine PlGF:

## Set 1

      TCT CCT CTG GTA TCA GCG TCT (SEQ ID NO: 67)  
       GCA CTG AAT TCC TGA GTG TCT (SEQ ID NO: 68)

## Set 2

20      763-743      TGG TGA TTG TGC CTT GAA GGA (SEQ ID NO: 69)  
       TCC ATG CCC CTT ATC ATG GAG (SEQ ID NO: 70)

## Set 3

25      88-108      TGA AGG ACC TTG GCT CTG GAT (SEQ ID NO: 71)  
       AAT AGA GGG TAG GTA CCA GCA (SEQ ID NO: 72)

30      PCR was performed with each primer set 1. If a distinct band was visible after this round of PCR, then the band was excised and the PCR product was sequenced using the 5' primer. If the band was not distinct, it was excised, the PCR products was purified, and 10% of the purified PCR product was used for further amplification using primer set 2.

35      Alternatively, if there were multiple indistinct bands, then the PCR products from the reaction tube were purified using a commercially available kit (Qiagen), and 10% of the purified product was used for another round of PCR using primer set 2. If a band was still indistinct it was excised, the PCR product

was purified, and 10% of the purified product was is used for further amplification using primer set 3. The distinct bands from the 2<sup>nd</sup> or 3<sup>rd</sup> amplification rounds are sequenced using the appropriate 5' primer. Sequences were compared to the known gene sequence to identify alternative splice forms.

5 One alternative splice form was identified in VEGF and VEGFB, and two were found in VEGFD (see Fig. 1 for identification of VEGFD#1; SEQ ID NO: 77 below). Amino acid translation of these sequences provided four VEGF peptides which contain amino acid sequences unique to the VEGF alternative splice forms (hereinafter "VEGF peptides"). The partial coding sequences of  
10 the alternatively spliced VEGF mRNAs, and the VEGF peptides encoded by the mRNA partial sequences, are provided below.

#### VEGF Alt. splice #1

15 R T K P E K C D K P R R (SEQ ID NO:73)  
AGA ACA AAG CCA GAA AA^A TGT GAC AAG CCA AGG CGG (SEQ ID NO:74)  
505^637

20 SEQ ID NO: 73 represents the peptide encoded by an alternatively spliced mRNA (SEQ ID NO: 74) spliced to create a junction of nucleotides 505 and 637, bringing together two normally distant sequences. The reading frame of mRNA is preserved, and a new codon is also formed at the splice junction (AAA encoding for a lysine residue).

#### 25 VEGFB Alt. splice #1

V V K Q L V Q T P P L P P (SEQ ID NO:75)  
30 GTG GTC AAA CAA CTA GT^G CAG ACG CCG CCG CTT CCT CCA (SEQ ID NO:76)  
300^678

35 SEQ ID NO: 75 represents the peptide encoded by an alternatively spliced mRNA (SEQ ID NO: 76), spliced to create a junction of nucleotides 300 and 678. The splice junction recreates the native valine at this position, but the subsequent codons are out of frame with the native reading frame of normal VEGFB, so that novel amino acids are produced from nucleotide 679 onward.

VEGFD Alt. splice #1

5 H G P V K M S S F Q E T (SEQ ID NO:77)  
CAT GGA CCA GTG AAG^ATG TCC TCA TTC CAA GAA ACT (SEQ ID NO:78)  
185^752

SEQ ID NO: 77 represents the peptide encoded by an alternatively spliced mRNA (SEQ ID NO: 78), spliced to create a junction of nucleotides 185 and 752. The splice junction shifts the codons out of frame at nucleotide 752 relative to the native reading frame of VEGFD, so that novel amino acids are produced from this point onward.

VEGFD Alt. splice #2

15

L	E	R	S	E	S	C	E	D	R	C	P	(SEQ ID NO:79)
TTG	GAA	CGA	TCT	GAA^AGC	TGT	GAG	GAC	AGA	TGT	CCT		(SEQ ID NO:80)
				238^1047								

20 SEQ ID NO: 79 represents the peptide encoded by an alternatively spliced mRNA (SEQ ID NO: 80), spliced to create a junction of nucleotides 238 and 1047. The splice junction shifts the codons out of frame at nucleotide 1047 relative to the native reading frame of VEGFD, so that novel amino acids are produced from this point onward.

25           It was confirmed that the VEGF alternative splice forms were specific to the tumor and not found in normal tissue. For the HC2 20d2/c cell model, mRNA from NIH-3T3 cells was subjected to the same PCR conditions using the 3 nested sets of primers described above. NIH 3T3 cells are the cells from which HC2 20d2/c cell line was derived. Either no band or only the normally  
30       spliced mRNA was detected for mouse VEGF, VEGFB or VEGFD. Exemplary results are shown in Fig. 1B, which reveals that only the normally spliced VEGFD mRNA was present in NIH-3T3 cells.

For the MMTV-neu mouse tumor model (see Example 3, below), normal cells (fibroblasts) were isolated by explant culture as follows. Skin was excised from the mice, trypsinized and then placed into cell culture using DMEM with 5% fetal bovine serum as the culture media. Fibroblasts were allowed to

migrate out from the excised skin and attach to the culture dish, whereupon they were propagated for 5-7 passages. The mRNA from the cultured fibroblasts was harvested, and subjected to the same PCR conditions as the mRNA isolated from MMTV mouse tumor cells using the three nested sets of PCR primers described above. PCR amplification of mRNA from normal MMTV-neu mouse cells revealed no band for the alternative splice form VEGFB, but showed an intact VEGFD band similar to that shown in Fig. 1B, representing the normally spliced mRNA.

The VEGF peptides listed above were synthesized by conventional methods. To avoid potential immune recognition of the normal VEGF family member, the VEGF peptides contained no more than 6 ordinarily contiguous amino acids from the corresponding normal protein. A peptide homodimer was made by adding a cysteine residue to the C-terminus of SEQ ID NO: 73 to give RTKPEKCDKPRRC (SEQ ID NO: 81). Dimerization was accomplished by controlled oxidation of the added C-terminal cysteine residues of SEQ ID NO: 81.

#### **Example 2 - Regression of Tumors by Treatment with VEGF Peptides**

The VEGF peptides and the SEQ ID NO: 85 homodimer were evaluated for their ability to elicit an anti-tumor immune response in a mouse tumor model. A total of 112 syngeneic mice were divided into eight treatment groups of 14 mice each, and injected with HC2 20d2/c tumor cells. Four days post-injection, the first through fifth treatment groups were vaccinated in the left inguinal area with 100 µg of either SEQ ID NO: 73, SEQ ID NO: 75, SEQ ID NO: 77, SEQ ID NO: 79, or the SEQ ID NO: 81 dimer diluted in 100 µl of PBS mixed with 45 ng of murine GM-CSF as an adjuvant. The total volume of phosphate buffered saline (PBS) was 150 microliters with 2 mg/ml mouse serum albumin as a carrier. The sixth treatment group was vaccinated as above with a combination of all four VEGF peptides and the SEQ ID NO: 81 homodimer (60 µg each) in a total of 200 microliters of PBS with 45 ng of murine GM-CSF and 2 mg/ml mouse serum albumin. The seventh treatment group was vaccinated as

above with 100 µg of a peptide derived from a mutant epidermal growth factor receptor (EGFR) protein called EGFRvIII (SEQ ID NO: 82). The vaccine composition also contained 45 ng of murine GM-CSF and 2 mg/ml mouse serum albumin. The EGFRvIII mutation is the result of a genomic rearrangement in the EGFR gene, and the EGFRvIII peptide (SEQ ID NO: 82) is reported to induce an immune response against tumor cells expressing the mutant receptor. The eighth treatment group was vaccinated with GM-CSF and 2 mg/ml mouse serum albumin in PBS with no peptide, as a control. All treatment groups were then injected once daily for the next 3 days with the 45 ng GM-CSF in the original area of vaccination.

Mice that received GM-CSF alone exhibited on average a progression of tumors 5 days after vaccination, and then a moderate level of regression thereafter (Fig. 2, "HC2 only"). This regression is most likely due to spontaneous rejection of the mutant EGFRvIII protein which is expressed in HC2 20d2/c tumor cells. Mice that received the EGFRvIII peptide also exhibited progression of tumors for approximately 5 days, but the progression was not as dramatic as the control mice and there is distinct regression noted thereafter (Fig. 2, "APLEEK"). The regression pattern observed for EGFRvIII vaccination is similar to previous results obtained with this peptide. (Moscatello, D.K., *Cancer Research* 57:1419-1424, 1997).

Fig. 2 shows that all four of the monomeric VEGF peptides and the SEQ ID NO: 81 homodimer induce tumor regression to some degree, which is most notable 12 days after vaccination. For two of the peptides, SEQ ID NO: 75 and SEQ ID NO: 81 (Fig. 2, "VVKQL" and "HGPVK"), regression is seen until ~20 days after vaccination; the tumors, however, progress from that point onward. Mice vaccinated with the SEQ ID NO: 73 peptide synthesized without an additional cysteine (Fig. 2, "RTKPEK no C") exhibited a pattern of regression similar to that found for the EGFRvIII peptide. Mice vaccinated with the SEQ ID NO: 81 homodimer or the SEQ ID NO: 79 peptide (Fig. 2, "RTKPEK with C" and "LERSE") show a strong reduction in average tumor volumes by the end of the study, although SEQ ID NO: 81 homodimer treatment group initially shows tumor progression. Mice vaccinated with a combination of all four



VEGF peptides and SEQ ID NO: 81 homodimer exhibit no tumor progression, and showed the greatest reduction in tumor volume of all treatment groups (Fig. 2, "Combo 5").

These results demonstrate that administering vaccine compositions comprising peptides based on VEGF family alternative splice forms elicit an effective anti-tumor immune response and causes tumor regression. Moreover, administration of a multimer or admixture of the VEGF peptides can further enhance the anti-tumor effect.

10        **Example 3 - Delaying Onset of Breast Cancer Tumors by Treatment With VEGF Peptides**

The ability of the VEGF peptides to prevent or delay the onset of tumors in MMTV-neu mice was evaluated. MMTV-neu mice are transgenic mice carrying an oncogenic form of the human *neu* oncogene under the control of the MMTV promoter, which drives expression of this oncogene in mammary tissue. 100% of female MMTV-neu mice develop multiple mammary tumors within 5-6 months of birth, which progress and eventually require sacrifice of the animal. Analysis of MMTV-neu mouse mammary tumors for VEGF family member alternative splice forms revealed alternative splice forms comprising the VEGF peptides SEQ ID NO: 73 and SEQ ID NO: 77.

Nine littermate MMTV-neu female mice were used in the experiment. One treatment group of three mice were initially vaccinated at 6 weeks of age with a combination of 60 micrograms each of SEQ ID NO: 73, SEQ ID NO: 77, and the SEQ ID NO: 81 homodimer with 45 ng of GM-CSF as the adjuvant. The mice are then vaccinated with the same composition at 5, 6, and 7 months of age. A control group of three mice received 45 ng GM-CSF alone as the adjuvant. A control group of three females received only 45 ng of GM-CSF. Both groups of mice were injected with 45 ng of GM-CSF at the original site of injection for an additional 3 days. This same cycle of vaccination was repeated at 5, 6, and 7 months of age. A second control group of three females received no treatment.

The results are given in Fig. 3, and show that untreated mice or mice given only GM-CSF develop tumors by 158 days after birth. All animals in

both control groups had tumors by 192 days after birth (Fig. 3A, "GM-CSF" and "No treatment"). In contrast, mice in the treatment group did not develop tumors until 192 days of age, and all animals in the treatment group did not have tumors until 226 days after birth (Fig. 3A, "Combo"). The total tumor volume per animal also revealed a difference in overall tumor burden between the treatment and control groups. By day 240, two of the untreated mice and one of the GM-CSF only mice attained total tumor volumes of greater than 3000 mm<sup>3</sup>, necessitating sacrifice of the animals (Fig 3B, "GM-CSF" and "No treatment"). However, in the treatment group the greatest tumor burden at day 240 was less than 1200 mm<sup>3</sup>.

Thus, vaccination with compositions comprising VEGF peptides delayed the onset of tumor formation in a mouse model of human breast cancer, and resulted in a significantly reduced tumor burden.

**Example 4 - Antibody response in MMTV-Neu mice vaccinated with a combination of VEGF peptides**

A "dot blot" analysis was performed to assess whether an antibody response was generated in MMTV-neu mice which were vaccinated with a combination of VEGF peptides. Three female MMTV mice were injected with a combination of 60 micrograms each of SEQ ID NO: 73, SEQ ID NO: 77, and the SEQ ID NO: 81 homodimer with 45 ng of GM-CSF as the adjuvant (COMBO) as in Example 3. Three female MMTV-neu mice that were left untreated (No Treatment) and three female MMTV-neu mice that were injected with 45 ng GM-CSF alone (GM-CSF) were used as controls. The dot blots were prepared by separately spotting 1 microgram of BSA, SEQ ID NO: 82 ("EGFRvIII"), SEQ ID NO: 73 ("R-pep"), SEQ ID NO: 81 homodimer ("RC-pep"), SEQ ID NO: 81 ("H-pep"), SEQ ID NO: 79 ("L-pep") or SEQ ID NO: 75 ("V-pep") onto nitrocellulose membranes. One membrane was prepared for each experimental and control animal. The membranes were then incubated with serum taken from the appropriate control or experimental animal at 2 months after the last injection, and diluted 1:100. The membranes were then

washed and incubated  $^{125}\text{I}$  anti-mouse secondary antibody, washed again and exposed to x-ray film.

The untreated animals (No Treatment; Fig. 4A) or those that received GM-CSF alone (GM-CSF; Fig. 4B) did not show an antibody response against any VEGF or control peptide tested. In contrast, all three animals that had been immunized with SEQ ID NO: 73, SEQ ID NO: 77 and SEQ ID NO: 85 (COMBO; Fig. 4C) showed a strong antibody reaction against SEQ ID NO: 77. In addition, two of the animals demonstrated an antibody response against SEQ ID NO: 73 and SEQ ID NO: 81. However no animal from the immunized group showed an antibody reaction against the BSA control or the three control peptides (EGFRvIII, L-pep, and V-pep) with which the animals were not vaccinated.

#### **Example 5 - Generation of Cytotoxic T lymphocyte Activity by VEGF Peptides**

An ELISPOT assay was performed to show that cytotoxic T lymphocyte activity was elicited by VEGF family peptides, as follows. Splenocytes were isolated from mice that were inoculated with HC2 20d2/c tumor cells and subsequently immunized with SEQ ID NO: 73 ("R-pep"), SEQ ID NO: 75 ("V-pep") or SEQ ID NO: 82 ("EGFRvIII") plus GM-CSF that showed tumor regression, or from a mouse inoculated with SEQ ID NO: 75 ("V-pep") and GM-CSF that showed no regression were evaluated in the assay. Splenocytes from mice inoculated with GM-CSF only were used as a control ("control"). HC2 20d2/c tumor cells pulsed with 10 micrograms/ml of the immunizing peptide, or mouse serum albumin (for splenocytes from GM-CSF only treated animals) were used as the target cells for the treatment and control splenocytes, respectively. Untreated HC2 20d2/c tumor cells were used as negative control target cells.

The splenocytes were incubated at various ratios (from 10:1 to 2:1) with target cells in triplicate, and lytic events were identified with an ELISPOT assay using anti-interferon-gamma antibody as the cytokine capture antibody. The specific spots per  $10^6$  cells were quantitated using the lytic events from

untreated target cells as the background, and then performing linear regression analysis. The results are shown in Fig. 5.

Fig. 5 shows that the mice immunized with either SEQ ID NO: 73 ("R-pep") or SEQ ID NO: 75 ("V-pep") and which had undergone tumor regression had strong CTL responses when target cells were pulsed with the vaccinating peptide. These responses were greater than that seen for the mouse treated with SEQ ID NO: 82 ("EGFRvIII") which had undergone tumor regression. In contrast, splenocytes from the mouse treated with only GM-CSF, or the mouse vaccinated with SEQ ID NO: 73 ("V-pep"), neither of which had undergone tumor regression, showed poor CTL responses.

**Example 6 - Generation of Cytotoxic T lymphocyte Activity by Admixtures of VEGF Peptides**

An ELISPOT assay is performed to show that cytotoxic T lymphocyte activity is elicited by VEGF family peptides, as follows. Splenocytes are isolated from mice that are inoculated with HC2 20d2/c tumor cells and subsequently immunized with a combination of 60 micrograms each of SEQ ID NO: 73, SEQ ID NO: 77, and the SEQ ID NO: 81 homodimer with 45 ng of GM-CSF as the adjuvant, or SEQ ID NO: 82 ("EGFRvIII") plus 45 ng GM-CSF. Mice inoculated with GM-CSF only are used as a control ("control"). HC2 20d2/c tumor cells pulsed with 10 micrograms/ml of the immunizing peptides, mouse serum albumin (as positive control), or untreated HC2 20d2/c tumor cells (negative control) are used as the target cells. The splenocytes are incubated at various ratios (from 10:1 to 2:1) with target cells in triplicate, and lytic events are identified with an ELISPOT assay using anti-interferon-gamma antibody as the cytokine capture antibody. The specific spots per  $10^6$  cells are quantitated using the lytic events from untreated target cells as the background, and then performing linear regression analysis.

The experiment is repeated with the following combinations of 60 micrograms each of the VEGF peptides as indicated:

- 1) SEQ ID NO: 73 and SEQ ID NO: 77;
- 2) SEQ ID NO: 77 and SEQ ID NO: 81; and

3) SEQ ID NO: 73; and SEQ ID NO: 81.

**Example 7 - Tumor Prevention and Regression with Peptides, Multimeric Peptides, and Peptide Admixtures**

5           Peptides of the invention derived from the alternative splice forms associated with breast cancer, ovarian cancer, prostate cancer, lung cancer, skin cancer, lymphoma, bladder cancer, and pancreatic cancer are tested for their ability to either prevent tumors or induce the regression of tumors in experimental mouse models.

10

**Mouse Models of Cancer**

          The mouse models used in the experiments are those in which the animals endogenously develop the relevant cancers or support the growth and tumorigenic properties of the relevant tumor-derived cell lines. For breast  
15   cancer, mice with a heterozygous deficiency for the *pten* gene or MMTV-neu transgenic mice are used; for ovarian cancer, mice with a heterozygous mutation in either BRCA1 or BRCA2 are used; for prostate cancer, transgenic mice with the SV40 early gene under the control of the probasin promoter are used; for lymphoma, mice with a homozygous deficiency for the p53 or p19<sup>ARF</sup>  
20   gene are used; for bladder cancer, mice fed *N*-butyl-*N*-(4-hydroxybutyl)nitrosamine (BBN) are used. Mouse models of lung and bladder cancer can be obtained, respectively, by introducing cells from the Lewis lung carcinoma cell line or the PANC02 murine pancreatic adenocarcinoma cell line into an appropriate mouse strain. A mouse model of skin cancer can be  
25   obtained by inducing tumors in mice by topical application of DMBA (7,12-dimethylbenz[*a*]anthracene).

### Tumor Prevention

Peptides of the invention which are associated with the cancers listed above are identified and synthesized as described above.

For those mouse models in which tumors are induced by a tumorigenic  
5 compound, or are produced from implanted tumor cells, the mice are initially  
vaccinated with approximately 50-500 micrograms of peptide mixed with 45 ng  
GM-CSF. The mice are then injected twice more with the same composition at  
intervals of 2 to 4 weeks. Mice receiving GM-CSF only are used as a control.  
After the third injection, the mice are inoculated with tumor cells or exposed to  
10 a tumorigenic compound in a dose known to produce tumors at a high incidence  
(i.e., in 75% to 90% or greater of the animals) in that particular host. The mice  
are then monitored for the time to first presentation of tumor, and the sizes of  
the tumors are measured every other day thereafter.

For those mouse models which spontaneously develop tumors, an initial  
15 vaccination with approximately 50-500 micrograms of peptide mixed with 45 ng  
GM-CSF is given at 6 weeks of age, the time at which the immune system is  
developed in mice, and then at 2 to 4 week intervals thereafter. Mice receiving  
GM-CSF only are used as a control. The mice are then monitored for the time  
to first presentation of tumor, and the sizes of the tumors are measured every  
20 other day thereafter.

### Tumor Regression

Peptides of the invention which are associated with the cancers listed above are identified and synthesized as described above.

25 For those mouse models in which tumors are induced by a tumorigenic  
compound, or are produced from implanted tumor cells, mice are initially  
inoculated with tumor cells or exposed to the tumorigenic compound. At a time  
period approximately four days prior to when tumors are expected to develop,  
the mice are vaccinated with approximately 50-500 micrograms of peptide  
30 mixed with 45 ng GM-CSF and injected twice more with the same composition  
at intervals of 2 to 4 weeks. Mice receiving GM-CSF only are used as a control.

The mice are monitored for the time to first presentation of tumor, and the sizes of the tumors are measured every other day thereafter.

For those mouse models which spontaneously develop tumors, an initial vaccination with approximately 50-500 micrograms of peptide mixed with 45 ng GM-CSF is given at 6 weeks of age, the time at which the immune system is developed in mice, and then at 2 to 4 week intervals thereafter. Mice receiving GM-CSF only are used as a control. The mice are monitored for the time to first presentation of tumor, and the sizes of the tumors are measured every other day thereafter.

10 *Tumor Prevention and Regression with Multimeric Peptides*

The experiments described above for demonstrating tumor prevention and regression in mouse models of cancer are repeated using dimeric, trimeric, tetrameric, pentameric or hexameric peptides of the invention which are associated with the particular cancer.

15

*Tumor Prevention and Regression with Peptide Admixtures*

The experiments described above for demonstrating tumor prevention and regression in mouse models of cancer are repeated using admixtures of two, three, four, five or six peptides of the invention which are associated with the particular cancer.

20

**Example 8 - Prevention or Regression of Tumors Formed by Syngeneic Mouse Tumor Cells Expressing Human Alternative Splice Forms**

Peptides of the invention of human origin associated with a cancer, as listed in Table 1, are identified and synthesized as described above. Expression vectors capable of expressing some or all of the human alternative splice form sequences from which the vaccinating peptides are derived are constructed according to standard techniques.

*Syngeneic Mouse Tumor Model*

30

An NIH-3T3 cell line is transfected with the SV40 T antigen to render it tumorigenic. Alternatively, an NIH-3T3 cell line is rendered tumorigenic by

being maintained continuously in cell culture for 30-40 passages, and tumorigenic cells which spontaneously arise are isolated and propagated.

The tumorigenic NIH-3T3 cells are transfected with the plasmid expression vector described above, and cells expressing the human alternative splice form sequences are selected and propagated by standard techniques. Tumorigenic NIH-3T3 cells expressing the human alternative splice form sequences are injected into NIH Swiss mice, and tumors are allowed to form. The tumors are excised from some animals and propagated in cell culture, where the cells maintain their ability to form tumors in animals. Expression of the human sequences is confirmed. These cells are then used in subsequent tumor prevention/regression experiments.

#### Tumor Prevention

NIH Swiss mice are initially vaccinated with approximately 50-500 micrograms of one or more peptides of the invention of human origin described above, mixed with 45 ng GM-CSF. The mice are then injected twice more with the same composition at intervals of 2 to 4 weeks. Mice receiving GM-CSF only are used as a control. After the third injection, the mice are inoculated with syngeneic tumor cells expressing human alternative splice form sequences, as described above. The mice are then monitored for the time to first presentation of tumor, and the sizes of the tumors are measured every other day thereafter.

#### Tumor Regression

NIH Swiss mice are initially inoculated with syngeneic tumor cells expressing the human alternative splice form, as described above. On the fourth day post inoculation, the mice are vaccinated with approximately 50-500 micrograms of one or more peptides of the invention of human origin described above, mixed with 45 ng GM-CSF. The mice are injected twice more with the same composition at intervals of 2 to 4 weeks. Mice receiving GM-CSF only are used as a control. The mice are monitored for the time to first presentation of tumor, and the sizes of the tumors are measured every other day thereafter.



All documents referred to herein are incorporated by reference in their entirety. While the present invention has been described in connection with the preferred embodiments and the various figures, it is to be understood that other similar embodiments may be used or modifications and additions made to the  
5 described embodiments for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather should be construed in breadth and scope in accordance with the recitation of the appended claims.

I claim:

1. A peptide comprising an amino acid sequence unique to an alternative splice form.
2. The peptide of claim 1, wherein the peptide is from 4 to 50 amino acids in length.
3. The peptide of claim 2, wherein the peptide is from 7 to 15 amino acids in length.
4. The peptide of claim 2, wherein the peptide is 8 or 9 amino acids in length.
5. The peptide of claim 1, wherein the peptide contains at least one normal amino acid sequence of 7 contiguous amino acids or less.
6. The peptide of claim 5, wherein the peptide contains at least one normal amino acid sequence of 6, 5, 4, 3, 2 or 1 contiguous amino acids.
7. The peptide of claim 5, wherein the peptide contains at least one normal amino acid sequence of 5 or 6 contiguous amino acids.
8. The peptide of claim 5, wherein the peptide contains a splice junction, a first normal amino acid sequence of 7 contiguous amino acids or less and a second normal amino acid sequence of 7 contiguous amino acids or less, wherein the first and second normal amino acid sequences flank the alternative splice junction.
9. The peptide of claim 8, wherein the first normal amino acid sequence has 6, 5, 4, 3, 2 or 1 contiguous amino acids and the second normal amino acid sequence has 6, 5, 4, 3, 2 or 1 contiguous amino acids.

10. The peptide of claim 8, wherein the first and second normal amino acid sequences each have 3 or 4 contiguous amino acids.

11. The peptide of claim 1, wherein the peptide contains at least one modification for coupling the peptide to a polyvalent platform or to another protein.

12. The peptide of claim 11, wherein the modification comprises additional amino acids added to the C- or N-terminus of the peptide.

13. The peptide of claim 12, wherein the amino acids added to the C- or N-terminus of the peptide are selected from the group consisting of tyrosine, cysteine, lysine, glutamic acid and aspartic acid.

14. The peptide of claim 13, wherein the amino acid added to the C- or N-terminus of the peptide is cysteine.

15. The peptide of claim 11, wherein the modification is selected from the group consisting of introduction of coupling sites by terminal-NH<sub>2</sub> acylation; thioglycolic acid amidation; terminal-carboxy amidation; and biotinylation.

16. The peptide of claim 1, which contains at least one D-amino acid.

17. The peptide of claim 1, selected from the group consisting of SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77; and SEQ ID NO: 79.

18. A multimer comprising two or more peptides of claim 1.

19. The multimer of claim 18, wherein the multimer is a homomultimer.

20. The multimer of claim 19 which is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

21. The multimer of claim 20, wherein the multimer is a dimer.

22. The dimer of claim 21 comprising two peptides of SEQ ID NO: 81.

23. The multimer of claim 18, wherein the multimer is a heteromultimer.

24. The multimer of claim 23 which is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

25. A method of identifying immunogenic peptides for treating a subject who has, or is at risk for having, a disease or condition in which diseased or abnormal cells produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells, comprising the steps of:

- 1) identifying at least one mRNA which encodes for the at least one alternative splice form;
- 2) determining at least a partial amino acid sequence of the at least one alternative splice form; and
- 3) generating at least one peptide comprising an amino acid sequence which is unique to the alternative splice form.

26. A method of treating a subject who has, or is at risk for having, a disease or condition in which diseased or abnormal cells produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells, comprising administering an effective amount of at least one peptide of claim 1 to the subject such that an immune response is generated against the diseased or abnormal cells.

27. The method of claim 26, wherein the immune response is an MHC HLA-class I or class II restricted cytotoxic T lymphocyte response, or an antibody response.

28. The method of claim 27, wherein the cytotoxic T lymphocyte response is a CD8<sup>+</sup> T lymphocyte response wherein CD8<sup>+</sup>, MHC class I-restricted T lymphocytes are activated.

29. The method of claim 27, wherein the cytotoxic T lymphocyte response is a CD4<sup>+</sup> T lymphocyte response wherein CD4<sup>+</sup>, MHC class II-restricted T lymphocytes are activated.

30. The method of claim 26, wherein the subject is a human being.

31. The method of claim 26, wherein the at least one peptide is selected from the group consisting of SEQ ID NO: 3; SEQ ID NO: 5; SEQ ID NO: 8; SEQ ID NO: 10; SEQ ID NO: 12; SEQ ID NO: 26; SEQ ID NO: 29; SEQ ID NO: 35; SEQ ID NO: 36; SEQ ID NO: 38; SEQ ID NO: 39; SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77; and SEQ ID NO: 79.

32. The method of claim 26, wherein the immune response generated against the diseased or abnormal cells is enhanced by modifying the peptide to prior to administering the peptide to the subject.

33. The method of claim 32, wherein the peptide is modified by increasing the hydrophobicity of the peptide N-terminus.

34. The method of claim 32, wherein the peptide is modified with at least one amino acid insertion, deletion, or substitution which increases binding affinity of the peptide to an MHC molecule.

35. The method of claim 32, wherein the stability of the peptide is increased by modifying the peptide prior to administering the peptide to the subject.

36. The method of claim 35, wherein the peptide is modified by capping the peptide with a D-amino acid, replacing at least one L-amino acid of the peptide with a D-amino acid, or reversing the amino acid sequence of the peptide and replacing at least one L-amino acid with a D-amino acid.

37. The method of claim 26, wherein two or more peptides are administered to the subject.

38. The method of claim 37, wherein the two or more peptides comprise a multimer.

39. The method of claim 38, wherein the multimer is a homomultimer.

40. The method of claim 39, wherein the multimer is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

41. The method of claim 40, wherein the multimer is a dimer.

42. The method of claim 41 comprising two peptides of SEQ ID NO: 81.

43. The method of claim 38, wherein the multimer is a heteromultimer.

44. The method of claim 43, wherein the multimer is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

45. The method of claim 37, wherein the two or more peptides comprise an admixture.

46. The method of claim 37, wherein the two or more peptides comprise overlapping epitopes from one or more alternative splice forms.

47. The method of claim 26, wherein the at least one peptide is administered to the subject in combination with peptides that present T-helper cell epitopes.

48. The method of claim 26, wherein the at least one peptide is administered to the subject in combination with at least one component that primes cytotoxic T lymphocytes.

49. The method of claim 48, wherein the at least one component that primes cytotoxic T lymphocytes comprises tripalmitoyl-S-glycerylcysteinyl-serine (P<sub>3</sub>CSS).

50. The method of claim 26, wherein the effective amount is about 1 microgram to about 2,000 mg of the at least one peptide per 70 kg of subject.

51. The method of claim 26, wherein the effective amount is about 1 microgram to about 500 mg of the at least one peptide per 70 kg of subject.

52. The method of claim 26, wherein the effective amount is about 10 micrograms to about 200 mg of the at least one peptide per 70 kg of subject.

53. The method of claim 26, wherein the effective amount is about 50 micrograms to about 100 mg of the at least one peptide per 70 kg of subject.

54. The method of claim 26, wherein the effective amount of the at least one peptide is administered in a single dose.

55. The method of claim 26, wherein the effective amount of the at least one peptide is administered in multiple doses.

56. The method of claim 26, wherein the effective amount of the at least one peptide is administered enterally.

57. The method of claim 56, wherein the enteral route of administration is selected from the group consisting of oral; rectal; and intranasal.

58. The method of claim 26, wherein the effective amount of the at least one peptide is administered parenterally.

59. The method of claim 58, wherein the parenteral route of administration is selected from the group consisting of intravenous; intramuscular; intraarterial; intraperitoneal; intravaginal; intravesical; intradermal; intrapulmonary; inhalation; topical; subcutaneous; and instillation into the body.

60. The method of claim 26, wherein the at least one peptide is administered to a subject in combination with a carrier or adjuvant.

61. The method of claim 60, wherein the carrier is selected from the group consisting of keyhole limpet hemocyanin; thyroglobulin; albumins; tetanus toxoid; and polyamino acids.

62. The method of claim 60, wherein the adjuvant is selected from the group consisting of complete Freund's adjuvant; incomplete Freund's adjuvant; aluminum phosphate; aluminum hydroxide; polylecithins; emulsified oils; and alum.



63. The method of claim 26, wherein the at least one peptide is administered to a subject in combination with an immunostimulatory compound.

64. The method of claim 63, wherein the immunostimulatory compound is selected from the group consisting of cytokines and haptens.

65. The method of claim 64, where the cytokines are selected from the group consisting of GM-CSF; IL-12; IL-2; IL-4; IL-1alpha; and IL-18.

66. The method of claim 26, wherein the effective amount of the at least one peptide is administered to a subject by expression of at least one nucleic acid sequence encoding the at least one peptide in cells of the subject

67. The method of claim 66, wherein cells of the subject are infected with an attenuated viral host comprising the at least one nucleic acid.

68. The method of claim 67, wherein the attenuated viral host is vaccinia virus.

69. The method of claim 66, wherein a bacterial host comprising the at least one nucleic acid is introduced into a subject.

70. The method of claim 69, wherein the bacterial host is selected from the group consisting of BCG; *Salmonella typhi*; and *Listeria monocytogenes*.

71. The method of claim 66, wherein a yeast host comprising the at least one nucleic acid is introduced into a subject.

72. The method of claim 71, wherein the yeast host is *Saccharomyces cerevisiae* or *Schizosaccharomyces pombe*.

73. The method of claim 26, wherein the disease or condition is selected from the group consisting of stress; cancer; diseases or conditions of the immune system; metabolic disorders; connective tissue disorders; disorders of the arteries; inherited red cell membrane disorders; thyroid hormone repression; endometrial hyperplasia; Alzheimer's disease; and alcoholism.

74. The method of claim 73, wherein the cancer is selected from the group consisting of acute promyelocytic leukemia; acute lymphoblastic leukemia; myeloblastic leukemia; uterine cancer; thyroid cancer; gastrointestinal cancer; dysplastic and neoplastic cervical epithelium; melanoma; endometrial cancer; teratocarcinoma; colon cancer; desmoplastic round cell tumors; gastric cancer; breast cancer, ovarian cancer, prostate cancer, lung cancer, skin cancer, lymphoma, bladder cancer, and pancreatic cancer.

75. The method of claim 26, wherein the disease or disorder is selected from the group consisting of allergic response; x-linked agammaglobulinemia; immunity/inflammation; systemic lupus erythematosus; Goodpasture disease; phenylketonuria; non-insulin dependent diabetes; osteogenesis imperfecta; atherosclerosis; and hereditary elliptocytosis.

76. The method of claim 26, wherein the alternative splice form is produced from the CD44 gene; the estrogen receptor gene; or the FHIT gene.

77. The method of claim 26, wherein administering the at least one peptide to a subject comprises the steps of:

- 1) removing immune system effector cells from a subject;
- 2) maintaining the immune system effector cells in culture outside the body of the subject;
- 3) optionally enriching the immune system effector cells for a particular immune system effector cell type;
- 4) treating the cultured immune system effector cells with the at least one peptide;
- 5) optionally examining a portion of the treated immune system effector cells to confirm the presence of the at least one peptide within the cells and
- 6) reintroducing the treated immune system effector cells into the subject.

78. The method of claim 77, wherein the immune system effector cells are selected from the group consisting of dendritic cells; lymphokine-activated killer cells; natural killer cells; T-cells; macrophages; and combinations thereof.

79. The method of claim 77, wherein treatment of the immune system effector cells with the at least one peptide comprises direct exposure of the cells to the at least one peptide.

80. The method of claim 77, wherein treatment of the immune system effector cells with the at least one peptide comprises introduction of at least one nucleic acid encoding the at least one peptide into the cells.

81. The method of claim 77, wherein the treated immune system effector cells are reintroduced into the subject by intravenous infusion or direct injection into the bone marrow.

82. The method of claim 77, wherein about  $10^5$  to about  $10^8$  treated immune system effector cells per kilogram of subject body weight are reintroduced into the subject.

83. A method of preventing or delaying the onset of tumor development in a subject at risk for having a tumor in which tumor cells produce at least one alternative splice form, which alternative splice form is substantially absent from non-tumor cells, comprising administering to a subject an effective amount of at least one peptide of claim 1, such that an immune response is generated against the tumor cells.

84. The method of claim 83, wherein the tumor derives from a cancer selected from the group consisting of a uterine cancer; thyroid cancer; gastrointestinal cancer; dysplastic and neoplastic cervical epithelium; melanoma; endometrial cancer; teratocarcinoma; colon cancer; desmoplastic round cell tumors; gastric cancer; breast cancer, ovarian cancer, prostate cancer, lung cancer, skin cancer, lymphoma, bladder cancer, and pancreatic cancer.

85. The method of claim 83, wherein the subject is a human being.

86. The method of claim 83, wherein two or more peptides are administered to the subject.

87. The method of claim 86, wherein the two or more peptides comprise a multimer.

88. The method of claim 87, wherein the multimer is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

89. The method of claim 87, wherein the multimer is a dimer and comprises two peptides of SEQ ID NO: 81.

90. The method of claim 86, wherein the two or more peptides comprise an admixture.

91. The method of claim 83, wherein the at least one peptide is selected from the group consisting of SEQ ID NO: 8; SEQ ID NO: 10; SEQ ID NO: 26; SEQ ID NO: 29; SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77; and SEQ ID NO: 79.

92. A method of regressing a tumor in a subject having a tumor in which tumor cells produce at least one alternative splice form, which alternative splice form is substantially absent from non-tumor cells, comprising administering to a subject an effective amount of at least one peptide of claim 1, such that an immune response is generated against the tumor cells.

93. The method of claim 92, wherein the tumor derives from a cancer selected from the group consisting of a uterine cancer; thyroid cancer; gastrointestinal cancer; dysplastic and neoplastic cervical epithelium; melanoma; endometrial cancer; teratocarcinoma; colon cancer; desmoplastic round cell tumors; gastric cancer; breast cancer, ovarian cancer, prostate cancer, lung cancer, skin cancer, lymphoma, bladder cancer, and pancreatic cancer.

94. The method of claim 92, wherein the subject is a human being.

95. The method of claim 88, wherein two or more peptides are administered to the subject.

96. The method of claim 95, wherein the two or more peptides comprise a multimer.

97. The method of claim 96, wherein the multimer is selected from the group consisting of a dimer; trimer; tetramer; pentamer; and hexamer.

98. The method of claim 97, wherein the multimer is a dimer and comprises two peptides of SEQ ID NO: 81.

99. The method of claim 95, wherein the two or more peptides comprise an admixture.

100. The method of claim 92, wherein the at least one peptide is selected from the group consisting of SEQ ID NO: 8; SEQ ID NO: 10; SEQ ID NO: 26; SEQ ID NO: 29; SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77; and SEQ ID NO: 79.

101. A method for identifying peptides which induce MHC-restricted cytotoxic T lymphocyte responses in a subject, comprising the steps of:

- 1) obtaining peripheral blood lymphocytes;
- 2) exposing the peripheral blood lymphocytes to at least one peptide of claim 1 such that the peripheral blood lymphocytes are stimulated;
- 3) incubating the stimulated peripheral blood lymphocytes with target cells that either endogenously synthesize the alternative splice form from which the peptide is derived or are pulsed with the peptide; and
- 4) detecting lysis of the target cells.

102. The method of claim 101, wherein the target cells are autologously labeled and the detection of target cell lysis comprises measuring release of the autologous label from the lysed target cells.

103. The method of claim 101, wherein the detection of target cell lysis comprises detection of at least one cytokine released from activated peripheral blood lymphocytes upon lysis of the target cells.

104. The method of claim 102, wherein the at least one cytokine is interferon-gamma.

105. An antibody or antibody fragment that binds to specific epitopes on a peptide selected from the group consisting of SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77; and SEQ ID NO: 79.

106. The antibody of claim 105 which is humanized.

107. The antibody of claim 105 which is a polyclonal antibody.

108. The antibody of claim 105 which is a monoclonal antibody.

109. A hybridoma producing the monoclonal antibody of claim 108.

110. A method of treating a subject having, or at risk for having, a disease or condition in which diseased or abnormal cells produce at least one alternative splice form, which alternative splice form is substantially absent from normal cells, comprising administering to a subject an effective amount of at least one antibody specific to an amino acid sequence unique to the alternative splice form, such that one or more clinical symptoms in the subject are ameliorated or the number of diseased or abnormal cells in the subject is reduced.

111. The method of claim 110, wherein the at least one antibody is a monoclonal antibody.

112. The method of claim 110, wherein the at least one antibody is humanized.

113. The method of claim 111, wherein the monoclonal antibody binds to specific epitopes on a peptide selected from the group consisting of SEQ ID NO: 3; SEQ ID NO: 5; SEQ ID NO: 8; SEQ ID NO: 10; SEQ ID NO: 12; SEQ ID NO: 26; SEQ ID NO: 29; SEQ ID NO: 35; SEQ ID NO: 36; SEQ

ID NO: 38; SEQ ID NO: 39; SEQ ID NO: 73; SEQ ID NO: 75; SEQ ID NO: 77;  
and SEQ ID NO: 79.

114. The method of claim 110, wherein the effective amount is about 0.1 mg/kg to about 100 mg/kg of body weight.

115. The method of claim 110, wherein the effective amount is about 50 mg/kg to about 100 mg/kg of body weight.

116. The method of claim 110, wherein the effective amount is about 10 mg/kg to about 20 mg/kg of body weight.

117. A pharmaceutical composition comprising at least one peptide of claim 1 and a pharmaceutically acceptable carrier.

118. The pharmaceutical composition of claim 117 which is encapsulated in a liposome.



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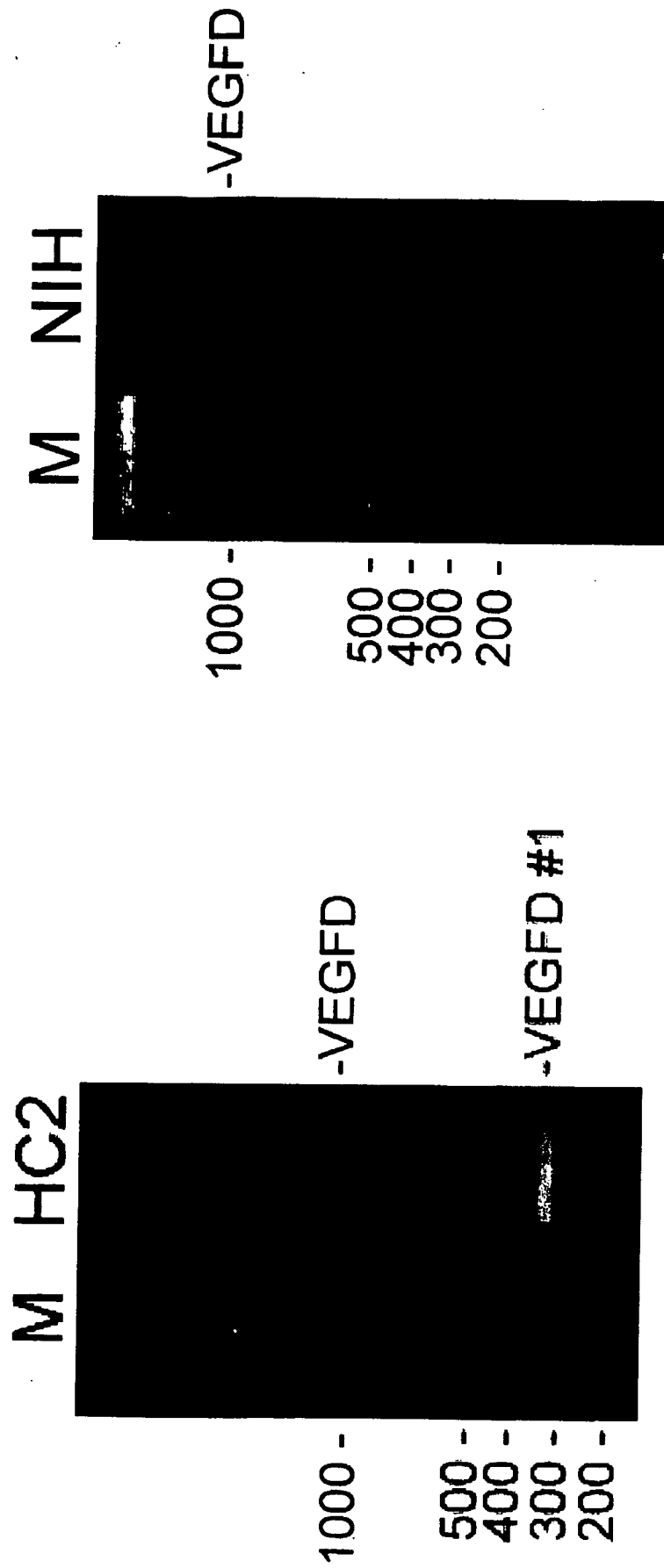


FIG. 1A

FIG. 1B

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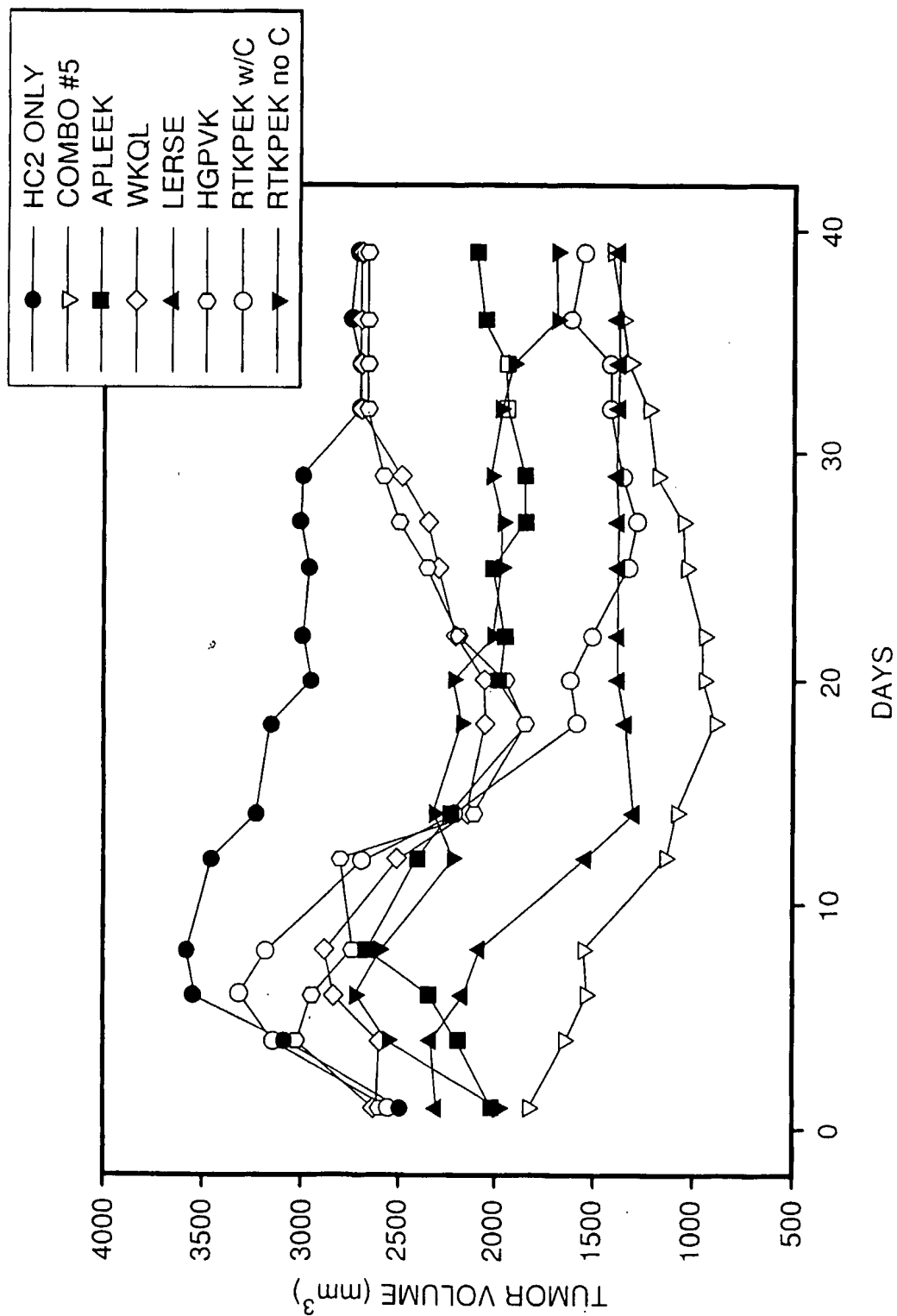


FIG. 2

FIG. 3A

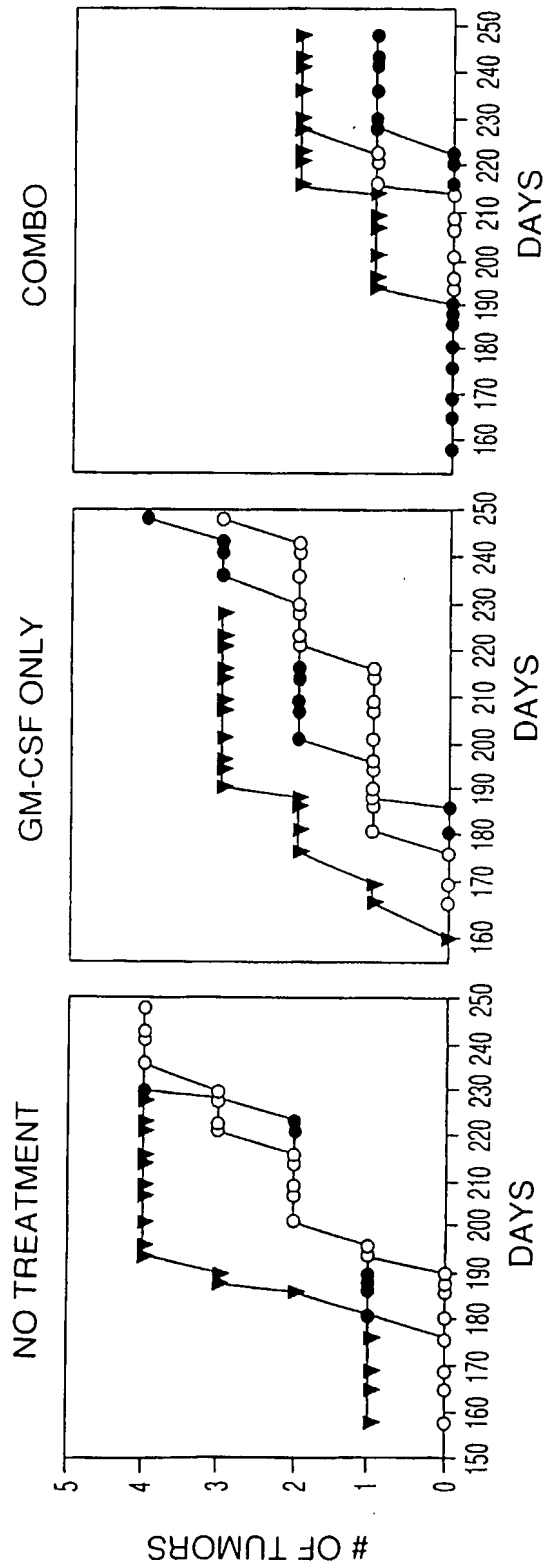
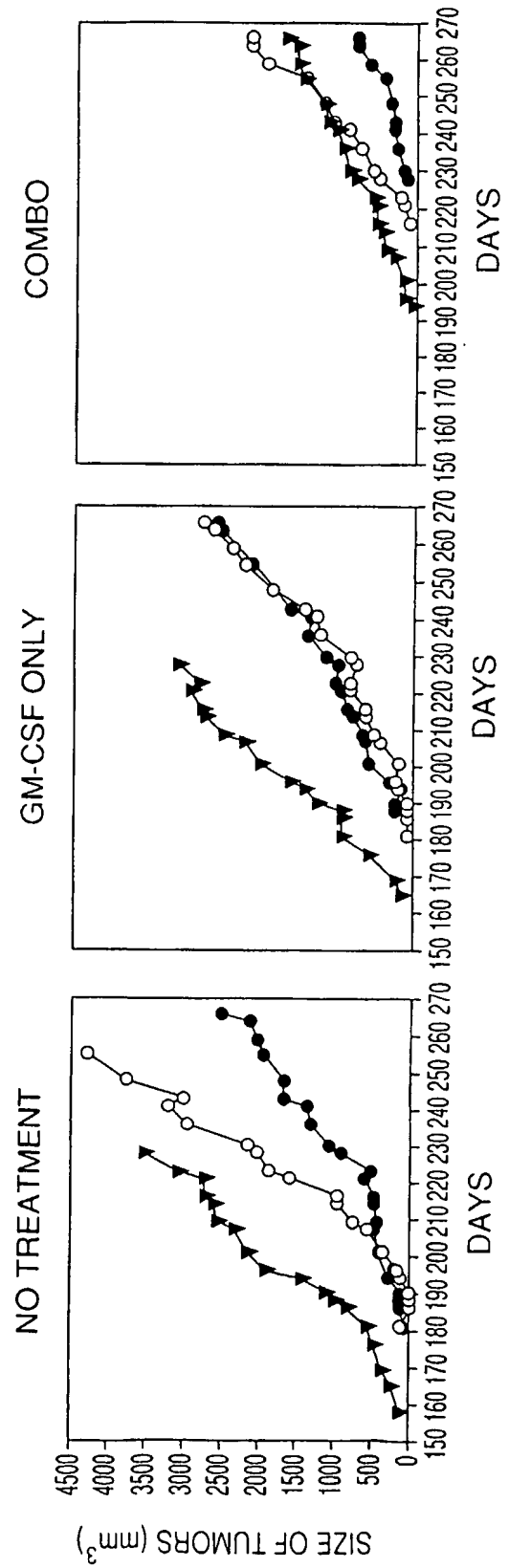


FIG. 3B



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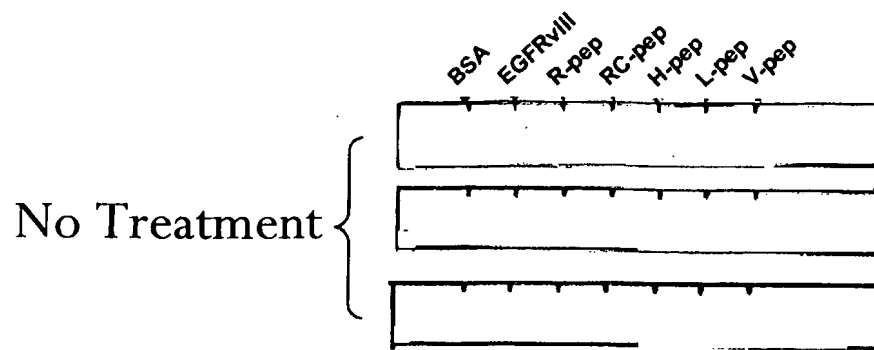


FIG. 4A

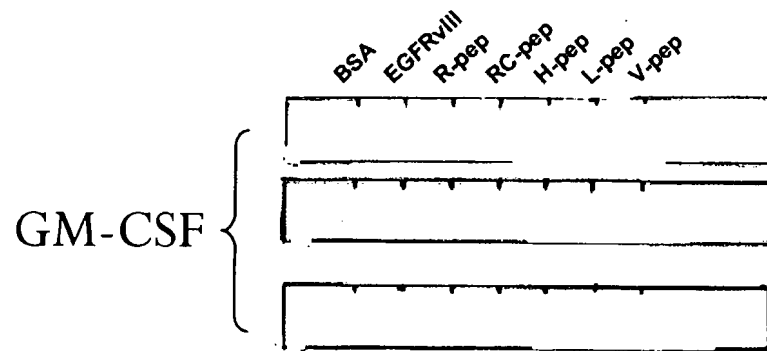


FIG. 4B

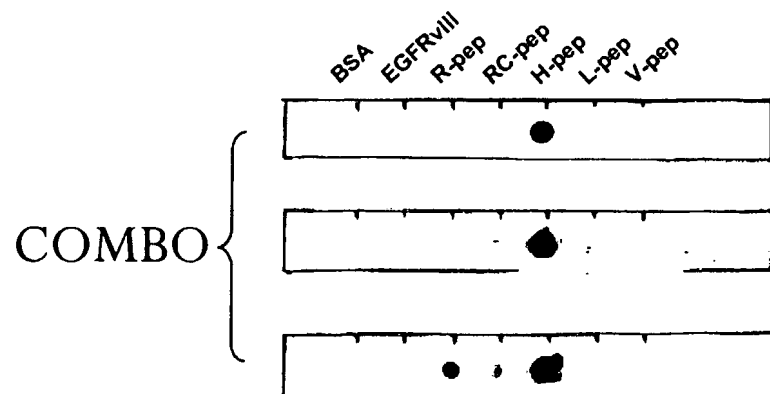


FIG. 4C

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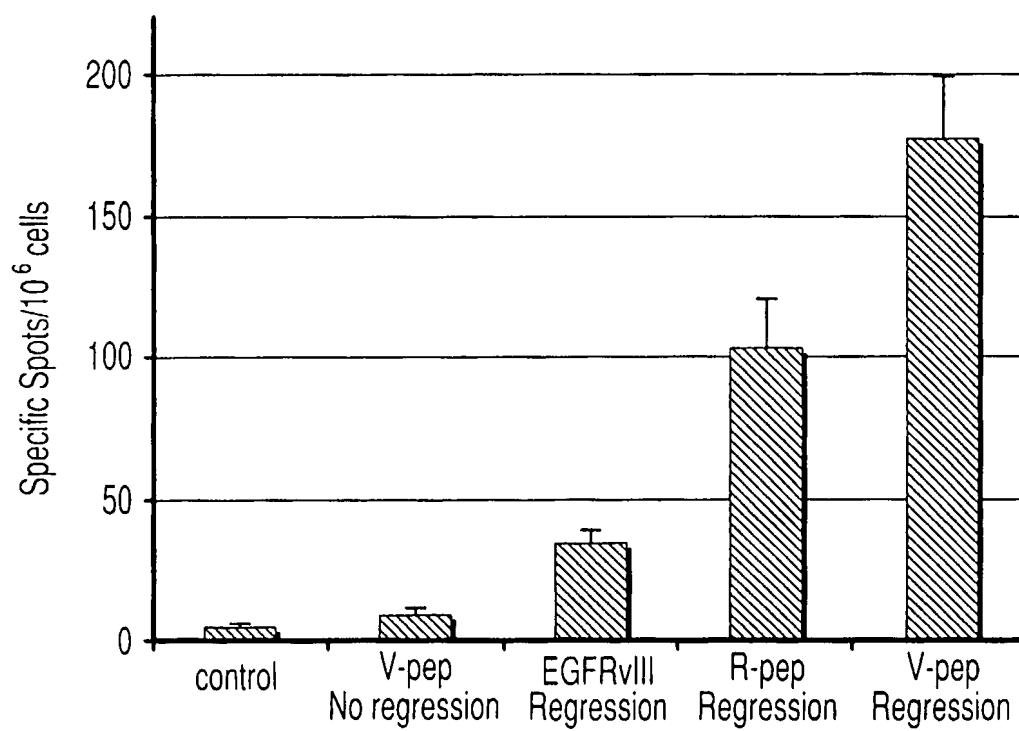


FIG. 5

## SEQUENCE LISTING

<110> Thomas Jefferson University  
Albert J. Wong

<120> Alternative Splice Forms of Proteins as  
Basis for Multiple Therapeutic Modalities

<130> 8321-81 PC

<150> US 60/293,791

<151> 2001-05-25

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 50      55      60
Val Lys Arg Gln Arg Ser Asp Pro Gln Ala Gln Leu Glu Ala Met Glu
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 85      90      95
Asn Ile Ile His Val Thr Gly Thr Lys Gly Lys Gly Ser Thr Cys Ala
 100      105      110
Phe Thr Glu Arg Ile Leu Arg Asn Tyr Gly Leu Lys Thr Gly Phe Phe
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Trp Gln Leu Pro Leu Ala Pro Val Phe Arg Pro Thr Pro His Met Arg
 340      345      350
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 355      360      365
Arg Gly Pro Leu Thr Trp Tyr Leu Asp Gly Ala His Thr Thr Ser Ser
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Val Gln Ala Cys Val His Trp Tyr Arg Gln Ser Leu Glu Arg Ser Lys
 385      390      395      400
Arg Thr Asp Gly Gly Ser Glu Val His Ile Leu Leu Phe Asn Ser Thr
 405      410      415
Gly Asp Arg Asp Ser Ala Ala Leu Leu Lys Leu Leu Gln Pro Cys Gln
 420      425      430
Phe Asp Tyr Ala Val Phe Cys Pro Asn Val Thr Glu Val Ser Ser Ile
 435      440      445
Gly Asn Ala Asp Gln Gln Asn Phe Thr Val Thr Leu Asp Gln Val Leu
 450      455      460
Leu Arg Cys Leu Gln His Gln Gln His Trp Asn Gly Leu Ala Glu Lys
 465      470      475      480
Gln Ala Ser Ser Asn Leu Trp Ser Ser Cys Gly Pro Asp Pro Ala Gly
 485      490      495
Pro Gly Ser Leu Leu Leu Ala Pro His Pro Pro Gln Pro Thr Arg Thr

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          500          505          510
Ser Ser Leu Val Phe Ser Cys Ile Ser His Ala Leu Leu Trp Ile Ser
          515          520          525
Gln Gly Arg Asp Pro Ile Phe Gln Pro Gln Ser Leu Pro Arg Asn Leu
          530          535          540
Leu Asn His Pro Thr Ala Asn Ser Gly Ala Ser Ile Leu Arg Glu Ala
545          550          555          560
Ala Ala Ile His Val Leu Val Thr Gly Ser Leu His Leu Val Gly Gly
          565          570          575
Val Leu Lys Leu Leu Asp Pro Ser Met Ser Gln
          580          585

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<210> 12  
 <211> 18  
 <212> PRT  
 <213> Mus musculus

<400> 12  
 Ala Val Ser Ala Arg Gly Ala Thr Thr Glu Gly Pro Ala Arg Arg Gly  
 1 5 10 15  
 Met Ser

<210> 13  
 <211> 237  
 <212> DNA  
 <213> Homo Sapiens

<220>  
 <221> CDS  
 <222> (1)...(237)

<400> 13  
 gac aga atc cct gct acc aat agg aat gat gtc aca ggt gga aga aga 48  
 Asp Arg Ile Pro Ala Thr Asn Arg Asn Asp Val Thr Gly Gly Arg Arg  
 1 5 10 15  
 gac cca aat cat tct gaa ggc tca act act tta ctg gaa ggt tat acc 96  
 Asp Pro Asn His Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr  
 20 25 30  
 tct cat tac cca cac acg aag gaa agc agg acc ttc atc cca gtg acc 144  
 Ser His Tyr Pro His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr  
 35 40 45  
 tca gct aag act ggg tcc ttt gga gtt act gca gtt act gtt gga gat 192  
 Ser Ala Lys Thr Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp  
 50 55 60  
 tcc aac tct aat gtc aat cgt tcc tta tca gga gac caa gac aca 237  
 Ser Asn Ser Asn Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
 65 70 75

<210> 14  
 <211> 79  
 <212> PRT  
 <213> Homo Sapiens

<400> 14  
 Asp Arg Ile Pro Ala Thr Asn Arg Asn Asp Val Thr Gly Gly Arg Arg  
 1 5 10 15  
 Asp Pro Asn His Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr  
 20 25 30

Ser His Tyr Pro His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr  
                   35                  40                  45  
 Ser Ala Lys Thr Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp  
                   50                  55                  60  
 Ser Asn Ser Asn Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
                   65                  70                  75

<210> 15  
 <211> 327  
 <212> DNA  
 <213> Homo Sapiens

<220>  
 <221> CDS  
 <222> (1)...(327)

<400> 15  
 gac aga atc cct gct acc aag cag agt aat tct cag agc ttc tct aca 48  
 Asp Arg Ile Pro Ala Thr Lys Gln Ser Asn Ser Gln Ser Phe Ser Thr  
   1                  5                  10                  15  
 tca cat gaa ggc ttg gaa gaa gat aaa gac cat cca aca act tct act 96  
 Ser His Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr Ser Thr  
                   20                  25                  30  
 ctg aca tca agc aat agg aat gat gtc aca ggt gga aga aga gac cca 144  
 Leu Thr Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg Asp Pro  
                   35                  40                  45  
 aat cat tct gaa ggc tca act act tta ctg gaa ggt tat acc tct cat 192  
 Asn His Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr Ser His  
                   50                  55                  60  
 tac cca cac acg aag gaa agc agg acc ttc atc cca gtg acc tca gct 240  
 Tyr Pro His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr Ser Ala  
   65                  70                  75                  80  
 aag act ggg tcc ttt gga gtt act gca gtt act gtt gga gat tcc aac 288  
 Lys Thr Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp Ser Asn  
                   85                  90                  95  
 tct aat gtc aat cgt tcc tta tca gga gac caa gac aca 327  
 Ser Asn Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
                   100                  105

<210> 16  
 <211> 109  
 <212> PRT  
 <213> Homo Sapiens

<400> 16  
 Asp Arg Ile Pro Ala Thr Lys Gln Ser Asn Ser Gln Ser Phe Ser Thr  
   1                  5                  10                  15  
 Ser His Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr Ser Thr  
                   20                  25                  30  
 Leu Thr Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg Asp Pro  
                   35                  40                  45  
 Asn His Ser Glu Gly Ser Thr Leu Leu Glu Gly Tyr Thr Ser His  
   50                  55                  60  
 Tyr Pro His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr Ser Ala  
   65                  70                  75                  80  
 Lys Thr Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp Ser Asn  
                   85                  90                  95  
 Ser Asn Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
                   100                  105

<210> 17  
 <211> 429  
 <212> DNA  
 <213> Homo Sapiens

<220>  
 <221> CDS  
 <222> (1)...(429)

<400> 17  
 gac aga atc cct gct acc aat atg gac tcc agt cat agt aca acg ctt 48  
 Asp Arg Ile Pro Ala Thr Asn Met Asp Ser Ser His Ser Thr Thr Leu  
 1 5 10 15  
 cag cct act gca aat cca aac aca ggt ttg gtg gaa gat ttg gac agg 96  
 Gln Pro Thr Ala Asn Pro Asn Thr Gly Leu Val Glu Asp Leu Asp Arg  
 20 25 30  
 aca gga cct ctt tca atg aca acg cag cag agt aat tct cag agc ttc 144  
 Thr Gly Pro Leu Ser Met Thr Thr Gln Gln Ser Asn Ser Gln Ser Phe  
 35 40 45  
 tct aca tca cat gaa ggc ttg gaa gaa gat aaa gac cat cca aca act 192  
 Ser Thr Ser His Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr  
 50 55 60  
 tct act ctg aca tca agc aat agg aat gat gtc aca ggt gga aga aga 240  
 Ser Thr Leu Thr Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg  
 65 70 75 80  
 gac cca aat cat tct gaa ggc tca act act tta ctg gaa ggt tat acc 288  
 Asp Pro Asn His Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr  
 85 90 95  
 tct cat tac cca cac acg aag gaa agc agg acc ttc atc cca gtg acc 336  
 Ser His Tyr Pro His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr  
 100 105 110  
 tca gct aag act ggg tcc ttt gga gtt act gca gtt act gtt gga gat 384  
 Ser Ala Lys Thr Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp  
 115 120 125  
 tcc aac tct aat gtc aat cgt tcc tta tca gga gac caa gac aca 429  
 Ser Asn Ser Asn Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
 130 135 140

<210> 18  
 <211> 143  
 <212> PRT  
 <213> Homo Sapiens

<400> 18  
 Asp Arg Ile Pro Ala Thr Asn Met Asp Ser Ser His Ser Thr Thr Leu  
 1 5 10 15  
 Gln Pro Thr Ala Asn Pro Asn Thr Gly Leu Val Glu Asp Leu Asp Arg  
 20 25 30  
 Thr Gly Pro Leu Ser Met Thr Thr Gln Gln Ser Asn Ser Gln Ser Phe  
 35 40 45  
 Ser Thr Ser His Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr  
 50 55 60  
 Ser Thr Leu Thr Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg  
 65 70 75 80  
 Asp Pro Asn His Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr

Ser	His	Tyr	Pro	85	His	Thr	Lys	Glu	Ser	90	Arg	Thr	Phe	Ile	Pro	95	Val	Thr
Ser	Ala	Lys	100	Thr	Gly	Ser	Phe	Gly	105	Val	Thr	Ala	Val	Thr	110	Val	Gly	Asp
Ser	Asn	115	Asn	Val	Asn	Arg	120	Ser	Leu	Ser	Gly	Asp	125	Gln	Asp	Thr		
	130					135						140						

<210> 19  
 <211> 555  
 <212> DNA  
 <213> Homo Sapiens

<220>  
 <221> CDS  
 <222> (1)...(555)

<400> 19																		
gac	aga	atc	cct	gct	acc	agt	acg	tct	tca	aat	acc	atc	tca	gca	ggc			48
Asp	Arg	Ile	Pro	Ala	Thr	Ser	Thr	Ser	Ser	Asn	Thr	Ile	Ser	Ala	Gly			
1				5					10					15				
tg	gag	cca	aat	gaa	gaa	agt	gaa	gat	gaa	aga	gac	aga	cac	ctc	agt			96
Trp	Glu	Pro	Asn	Glu	Glu	Ser	Glu	Asp	Glu	Arg	Asp	Arg	His	Leu	Ser			
			20					25					30					
ttt	tct	gga	tca	ggc	att	gat	gat	gat	gaa	gat	ttt	atc	tcc	agc	acc			144
Phe	Ser	Gly	Ser	Gly	Ile	Asp	Asp	Asp	Glu	Asp	Phe	Ile	Ser	Ser	Thr			
		35					40					45						
aat	atg	gac	tcc	agt	cat	agt	aca	acg	ctt	cag	cct	act	gca	aat	cca			192
Asn	Met	Asp	Ser	Ser	His	Ser	Thr	Thr	Leu	Gln	Pro	Thr	Ala	Asn	Pro			
	50					55					60							
aac	aca	ggt	ttg	gtg	gaa	gat	ttg	gac	agg	aca	gga	cct	ctt	tca	atg			240
Asn	Thr	Gly	Leu	Val	Glu	Asp	Leu	Asp	Arg	Thr	Gly	Pro	Leu	Ser	Met			
	65				70				75						80			
aca	acg	cag	cag	agt	aat	tct	cag	agc	ttc	tct	aca	tca	cat	gaa	ggc			288
Thr	Thr	Gln	Gln	Ser	Asn	Ser	Gln	Ser	Phe	Ser	Thr	Ser	His	Glu	Gly			
				85					90					95				
ttg	gaa	gaa	gat	aaa	gac	cat	cca	aca	act	tct	act	ctg	aca	tca	agc			336
Leu	Glu	Glu	Asp	Lys	Asp	His	Pro	Thr	Thr	Ser	Thr	Leu	Thr	Ser	Ser			
			100				105						110					
aat	agg	aat	gat	gtc	aca	ggt	gga	aga	aga	gac	cca	aat	cat	tct	gaa			384
Asn	Arg	Asn	Asp	Val	Thr	Gly	Gly	Arg	Arg	Asp	Pro	Asn	His	Ser	Glu			
		115				120						125						
ggc	tca	act	act	tta	ctg	gaa	ggt	tat	acc	tct	cat	tac	cca	cac	acg			432
Gly	Ser	Thr	Thr	Leu	Leu	Glu	Gly	Tyr	Thr	Ser	His	Tyr	Pro	His	Thr			
	130					135					140							
aag	gaa	agc	agg	acc	ttc	atc	cca	gtg	acc	tca	gct	aag	act	ggg	tcc			480
Lys	Glu	Ser	Arg	Thr	Phe	Ile	Pro	Val	Thr	Ser	Ala	Lys	Thr	Gly	Ser			
	145				150				155						160			
ttt	gga	gtt	act	gca	gtt	act	gtt	gga	gat	tcc	aac	tct	aat	gtc	aat			528
Phe	Gly	Val	Thr	Ala	Val	Thr	Val	Gly	Asp	Ser	Asn	Ser	Asn	Val	Asn			
				165					170					175				
cgt	tcc	tta	tca	gga	gac	caa	gac	aca										555
Arg	Ser	Leu	Ser	Gly	Asp	Gln	Asp	Thr										
			180					185										



<210> 20  
 <211> 185  
 <212> PRT  
 <213> Homo Sapiens

<400> 20  
 Asp Arg Ile Pro Ala Thr Ser Thr Ser Ser Asn Thr Ile Ser Ala Gly  
 1 5 10 15  
 Trp Glu Pro Asn Glu Glu Ser Glu Asp Glu Arg Asp Arg His Leu Ser  
 20 25 30  
 Phe Ser Gly Ser Gly Ile Asp Asp Glu Asp Phe Ile Ser Ser Thr  
 35 40 45  
 Asn Met Asp Ser Ser His Ser Thr Thr Leu Gln Pro Thr Ala Asn Pro  
 50 55 60  
 Asn Thr Gly Leu Val Glu Asp Leu Asp Arg Thr Gly Pro Leu Ser Met  
 65 70 75 80  
 Thr Thr Gln Gln Ser Asn Ser Gln Ser Phe Ser Thr Ser His Glu Gly  
 85 90 95  
 Leu Glu Glu Asp Lys Asp His Pro Thr Thr Ser Thr Leu Thr Ser Ser  
 100 105 110  
 Asn Arg Asn Asp Val Thr Gly Gly Arg Arg Asp Pro Asn His Ser Glu  
 115 120 125  
 Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr Ser His Tyr Pro His Thr  
 130 135 140  
 Lys Glu Ser Arg Thr Phe Ile Pro Val Thr Ser Ala Lys Thr Gly Ser  
 145 150 155 160  
 Phe Gly Val Thr Ala Val Thr Val Gly Asp Ser Asn Ser Asn Val Asn  
 165 170 175  
 Arg Ser Leu Ser Gly Asp Gln Asp Thr  
 180 185

<210> 21  
 <211> 561  
 <212> DNA  
 <213> Homo Sapiens

<220>  
 <221> CDS  
 <222> (1)...(561)

<400> 21  
 gac aga atc cct gct acc aca gcc tca gct cat acc agc cat cca atg 48  
 Asp Arg Ile Pro Ala Thr Thr Ala Ser Ala His Thr Ser His Pro Met  
 1 5 10 15  
 caa gga agg aca aca cca agc cca gag gac agt tcc tgg act gat ttc 96  
 Gln Gly Arg Thr Thr Pro Ser Pro Glu Asp Ser Ser Trp Thr Asp Phe  
 20 25 30  
 ttc aac cca atc tca cac ccc atg gga cga ggt cat caa gca gga aga 144  
 Phe Asn Pro Ile Ser His Pro Met Gly Arg Gly His Gln Ala Gly Arg  
 35 40 45  
 agg atg gat atg gac tcc agt cat agt aca acg ctt cag cct act gca 192  
 Arg Met Asp Met Asp Ser Ser His Ser Thr Thr Leu Gln Pro Thr Ala  
 50 55 60  
 aat cca aac aca ggt ttg gtg gaa gat ttg gac agg aca gga cct ctt 240  
 Asn Pro Asn Thr Gly Leu Val Glu Asp Leu Asp Arg Thr Gly Pro Leu  
 65 70 75 80  
 tca atg aca acg cag cag agt aat tct cag agc ttc tct aca tca cat 288  
 Ser Met Thr Thr Gln Gln Ser Asn Ser Gln Ser Phe Ser Thr Ser His  
 85 90 95

gaa ggc ttg gaa gaa gat aaa gac cat cca aca act tct act ctg aca 336  
 Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr Ser Thr Leu Thr  
 100 105 110  
 tca agc aat agg aat gat gtc aca ggt gga aga aga gac cca aat cat 384  
 Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg Asp Pro Asn His  
 115 120 125  
 tct gaa ggc tca act act tta ctg gaa ggt tat acc tct cat tac cca 432  
 Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr Ser His Tyr Pro  
 130 135 140  
 cac acg aag gaa agc agg acc ttc atc cca gtg acc tca gct aag act 480  
 His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr Ser Ala Lys Thr  
 145 150 155 160  
 ggg tcc ttt gga gtt act gca gtt act gtt gga gat tcc aac tct aat 528  
 Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp Ser Asn Ser Asn  
 165 170 175  
 gtc aat cgt tcc tta tca gga gac caa gac aca 561  
 Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
 180 185

<210> 22  
 <211> 187  
 <212> PRT  
 <213> Homo Sapiens

<400> 22  
 Asp Arg Ile Pro Ala Thr Thr Ala Ser Ala His Thr Ser His Pro Met  
 1 5 10 15  
 Gln Gly Arg Thr Thr Pro Ser Pro Glu Asp Ser Ser Trp Thr Asp Phe  
 20 25 30  
 Phe Asn Pro Ile Ser His Pro Met Gly Arg Gly His Gln Ala Gly Arg  
 35 40 45  
 Arg Met Asp Met Asp Ser Ser His Ser Thr Thr Leu Gln Pro Thr Ala  
 50 55 60  
 Asn Pro Asn Thr Gly Leu Val Glu Asp Leu Asp Arg Thr Gly Pro Leu  
 65 70 75 80  
 Ser Met Thr Thr Gln Gln Ser Asn Ser Gln Ser Phe Ser Thr Ser His  
 85 90 95  
 Glu Gly Leu Glu Glu Asp Lys Asp His Pro Thr Thr Ser Thr Leu Thr  
 100 105 110  
 Ser Ser Asn Arg Asn Asp Val Thr Gly Gly Arg Arg Asp Pro Asn His  
 115 120 125  
 Ser Glu Gly Ser Thr Thr Leu Leu Glu Gly Tyr Thr Ser His Tyr Pro  
 130 135 140  
 His Thr Lys Glu Ser Arg Thr Phe Ile Pro Val Thr Ser Ala Lys Thr  
 145 150 155 160  
 Gly Ser Phe Gly Val Thr Ala Val Thr Val Gly Asp Ser Asn Ser Asn  
 165 170 175  
 Val Asn Arg Ser Leu Ser Gly Asp Gln Asp Thr  
 180 185

<210> 23  
 <211> 193  
 <212> PRT  
 <213> Rattus Norvegicus

<400> 23  
 Gln Leu Arg Asn Phe Leu Lys Cys Ser Glu Asp Asn Pro Leu Phe Ala  
 1 5 10 15  
 Gly Ile Asp Cys Glu Val Phe Glu Ser Arg Phe Pro Thr Thr Met Ala  
 20 25 30

Leu Ser Val Leu Val Thr Ile Glu Met Cys Asn Ala Leu Asn Ser Val  
 35 40 45  
 Ser Glu Asn Gln Ser Leu Leu Arg Met Pro Pro Trp Leu Asn Pro Trp  
 50 55 60  
 Leu Leu Gly Ala Val Val Met Ser Met Ala Leu His Phe Leu Ile Leu  
 65 70 75 80  
 Leu Val Pro Pro Leu Pro Leu Ile Phe Gln Val Thr Pro Leu Ser Gly  
 85 90 95  
 Arg Gln Trp Gly Val Val Leu Gln Met Ser Leu Pro Val Ile Leu Leu  
 100 105 110  
 Asp Glu Ala Leu Lys Tyr Leu Ser Arg His His Val Asp Gly Val Leu  
 115 120 125  
 Glu Thr Phe Met Gln Ala Trp Cys Lys Gln Pro Leu Pro Gly Pro His  
 130 135 140  
 Thr Thr Arg Gly Trp Leu Pro Gly Cys His Phe Asn Gly Trp Glu Gln  
 145 150 155 160  
 Thr Glu Glu Phe Val Phe Ile Gln Glu Arg Trp Thr Val Ser Gly Leu  
 165 170 175  
 Gly Pro Glu Lys Lys Ala Arg Glu Arg Leu Gly Leu Val Ser Ala Ala  
 180 185 190  
 Ser

<210> 24  
 <211> 161  
 <212> PRT  
 <213> Homo Sapiens

<400> 24  
 Glu Ser Arg Phe Pro Thr Thr Met Ala Leu Ser Val Leu Val Thr Ile  
 1 5 10 15  
 Glu Met Cys Asn Ala Leu Asn Ser Val Ser Glu Asn Gln Ser Leu Leu  
 20 25 30  
 Arg Met Pro Pro Trp Met Asn Pro Trp Leu Leu Val Ala Val Ala Met  
 35 40 45  
 Ser Met Ala Leu His Phe Leu Ile Leu Leu Val Pro Pro Leu Pro Leu  
 50 55 60  
 Ile Phe Gln Val Thr Pro Leu Ser Gly Arg Gln Trp Val Val Val Leu  
 65 70 75 80  
 Gln Ile Ser Leu Pro Val Ile Leu Leu Asp Glu Ala Leu Lys Tyr Leu  
 85 90 95  
 Ser Arg Asn His Met His Ala Cys Leu Tyr Pro Gly Leu Leu Arg Thr  
 100 105 110  
 Val Ser Gln Ala Trp Ser Arg Gln Pro Leu Thr Thr Ser Trp Thr Pro  
 115 120 125  
 Asp His Thr Gly Leu Ala Ser Leu Gly Gln Gly His Ser Ile Val Ser  
 130 135 140  
 Leu Ser Glu Leu Leu Arg Glu Gly Gly Ser Arg Glu Glu Met Ser Gln  
 145 150 155 160  
 Lys

<210> 25  
 <211> 153  
 <212> PRT  
 <213> Homo sapiens

<400> 25  
 Glu Ser Arg Phe Pro Thr Thr Met Ala Leu Ser Val Leu Val Thr Ile  
 1 5 10 15  
 Glu Met Cys Asn Ala Leu Asn Ser Val Ser Glu Asn Gln Ser Leu Leu  
 20 25 30  
 Arg Met Pro Pro Trp Met Asn Pro Trp Leu Leu Val Ala Val Ala Met  
 35 40 45  
 Ser Met Ala Leu His Phe Leu Ile Leu Leu Val Pro Pro Leu Pro Leu

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      50      55      60
Ile Phe Gln Val Thr Pro Leu Ser Gly Arg Gln Trp Val Val Val Leu
65      70      75      80
Gln Ile Ser Leu Pro Val Ile Leu Leu Asp Glu Ala Leu Lys Tyr Leu
      85      90      95
Ser Arg Asn His Met His Ala Cys Leu Tyr Pro Gly Leu Leu Arg Thr
      100      105      110
Val Ser Gln Ala Trp Ser Arg Gln Pro Leu Thr Thr Ser Trp Thr Pro
      115      120      125
Asp His Thr Gly Ala Arg Asp Thr Ala Ser Ser Arg Cys Gln Ser Cys
      130      135      140
Ser Glu Arg Glu Glu Ala Gly Lys Lys
145      150

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<210> 26  
 <211> 17  
 <212> PRT  
 <213> Homo sapiens

<400> 26  
 Leu Ile Leu Val Gly Glu Pro Ser Ile Ser Thr Pro Asp Gly Thr Ile  
 1 5 10 15  
 Lys

<210> 27  
 <211> 101  
 <212> PRT  
 <213> Homo sapiens

<400> 27  
 Met Glu Asp Asp Glu Leu Thr Asp Ser Lys Leu Pro Ser His Ala Thr  
 1 5 10 15  
 His Ser Leu Phe Thr Cys Pro Glu Asn Glu Glu Met Val Leu Ser Asn  
 20 25 30  
 Ser Arg Ile Gly Lys Arg Arg Gly Glu Pro Leu Ile Leu Val Gly Glu  
 35 40 45  
 Pro Ser Ile Ser Thr Pro Asp Gly Thr Ile Lys Asp Arg Arg Leu Phe  
 50 55 60  
 Met His His Val Ser Leu Glu Pro Ile Thr Cys Val Pro Phe Arg Thr  
 65 70 75 80  
 Thr Lys Glu Arg Gln Glu Ile Gln Asn Pro Asn Phe Thr Ala Pro Gly  
 85 90 95  
 Gln Glu Phe Leu Ser  
 100

<210> 28  
 <211> 149  
 <212> PRT  
 <213> Homo sapiens

<400> 28  
 Ala Glu Lys Gln Ala Lys Ala Arg Glu Ser Gly Ser Ser Thr Ala Glu  
 1 5 10 15  
 Glu Gly Asp Phe Ser Lys Gly Pro Ile Arg Cys Asp Arg Cys Gly Tyr  
 20 25 30  
 Asn Thr Asn Arg Tyr Asp His Tyr Thr Ala His Leu Lys His His Thr  
 35 40 45  
 Arg Ala Gly Asp Asn Glu Arg Val Tyr Lys Cys Ile Ile Cys Thr Tyr  
 50 55 60  
 Thr Thr Val Ser Glu Tyr His Trp Arg Lys His Leu Arg Asn His Phe  
 65 70 75 80  
 Pro Arg Lys Val Tyr Thr Cys Gly Lys Cys Asn Tyr Phe Ser Asp Arg  
 85 90 95

Lys Asn Asn Tyr Val Gln His Val Arg Thr His Thr Gly Glu Arg Pro  
 100 105 110  
 Tyr Lys Cys Glu Leu Cys Pro Tyr Ser Ser Ser Gln Lys Thr His Leu  
 115 120 125  
 Thr Arg His Met Arg Thr His Ser Val Gly Tyr Gly Tyr His Leu Val  
 130 135 140  
 Ile Phe Thr Arg Val  
 145

<210> 29  
 <211> 13  
 <212> PRT  
 <213> Homo sapiens

<400> 29  
 Val Gly Tyr Gly Tyr His Leu Val Ile Phe Thr Arg Val  
 1 5 10

<210> 30  
 <211> 875  
 <212> DNA  
 <213> Homo sapiens

<400> 30  
 cgcttggcgg agctgtacgt gaagccgggc aacaaggaac gcggctggaa cgacccgccg 60  
 cagttctcat acgggctgca gaccagggcc ggcggaccca ggcgctcgct gcttaccaag 120  
 agggtagccg caccacagga tggatccccc agagtccccc catcagagac ttctcctggg 180  
 cctccccc aa tggggcctcc acctccttca agtaaggctc ccagggtccc acctgtgggg 240  
 agtggctcctg cctctggcgt ggagcccaca agtttcccag tcgagtctga ggctgtgatg 300  
 gaggatgtgc tgagaccttt ggaacaggca ttggaagact gccgtggcca cacaagggaag 360  
 caggtatgtg atgacatcag ccgacgcctg gcaactgtgc aggaacagtg ggctggagga 420  
 aagtgtgcaa tacctgtaaa gaagagaatg gctctactgg tgcaagagct ttcaagccac 480  
 cggtgggacg cagcagatga catccaccgc tccctcatgg ttgacctgt gactgagggtc 540  
 agtcagtggg tggtaggagt taaaagatta attgcagaaa agaggagtct gttttcagag 600  
 gaggcagcca atgaagagaa atctgcagcc acagctgaga agaaccatac cataccaggc 660  
 ttccagcagg ctccataatc ctcggttccc cagactcacc ggacaccatc tcctatgcct 720  
 tggagacctt ctgtcacttg gctcccttct taccaccacc aagactgtcc cactgggcct 780  
 gacccacctt tgaggggaaga agtcccacct gggccagagg gagttcatgt gttactcata 840  
 acatgcattt caataaaaac atctctgcgg tgggtg 875

<210> 31  
 <211> 672  
 <212> DNA  
 <213> Homo sapiens

<400> 31  
 cgcttggcgg agctgtacgt gaagccgggc aacaaggaac gcggctggaa cgacccgccg 60  
 cagttctcat acgggctgca gaccagggcc ggcggaccca ggcgctcgct gcttaccaag 120  
 agggtagccg caccacagga tggatccccc agagaagcag gtatgtgatg acatcagccg 180  
 acgcctggca ctgctgcagg aacagtgggc tggaggaaag ttgtcaatac ctgtaaagaa 240  
 gagaatggct ctactggtgc aagagctttc aagccaccgg tgggacgcag cagatgacat 300  
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(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
5 December 2002 (05.12.2002)

PCT

(10) International Publication Number  
**WO 02/097044 A3**

(51) International Patent Classification<sup>7</sup>: **A61K 38/00**,  
35/34, 38/24, C12P 21/06

(21) International Application Number: PCT/US02/16707

(22) International Filing Date: 28 May 2002 (28.05.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/293,791 25 May 2001 (25.05.2001) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,  
SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ,  
VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,  
GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent  
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,  
NE, SN, TD, TG).

**Published:**

— *with international search report*

(88) Date of publication of the international search report:  
28 August 2003

*For two-letter codes and other abbreviations, refer to the "Guid-  
ance Notes on Codes and Abbreviations" appearing at the begin-  
ning of each regular issue of the PCT Gazette.*

(54) Title: ALTERNATIVE SPLICE FORMS OF PROTEINS AS BASIS FOR MULTIPLE THERAPEUTIC MODALITIES

(57) Abstract: Peptides or antibodies derived from alternative splice forms of proteins associated with a disease or physiologic condition are used as therapeutic or prophylactic agents. Peptides or antibodies derived from alternative splice forms of the vascular endothelial growth factor (VEGF) family of proteins are particularly useful in preventing or delaying the onset of tumors and inducing tumor regression.



**WO 02/097044 A3**

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/16707

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61K 38/00, 35/34, 38/24; C12P 21/06

US CL : 514/12; 424/569; 435/252.3, 320.1, 69.1; 530/350, 399

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/12; 424/569; 435/252.3, 320.1, 69.1; 530/350, 399

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
SEQ SEARCH, WEST, STN CAS: MEDLINE CAPLUS EMBASE BIOSIS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,994,300 A (BAYNE et al) 30 November 1999 (30.11.1999), entire patent.	1, 5-7, 17, 25-26, 30-32, 50-63, 66-72 ----- 2-4, 8-16, 18-24, 27-29, 33-49, 64-65 and 73-76
X --- Y	US 5,726,152 A (BAYNE et al) 10 March 1998 (10.03.1998), entire patent.	1, 5-7, 17, 25-26, 30-32, 50-63, 66-72 ----- 2-4, 8-16, 18-24, 27-29, 33-49, 64-65, 73-76

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search

04 May 2003 (04.05.2003)

Date of mailing of the international search report

15 MAY 2003

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